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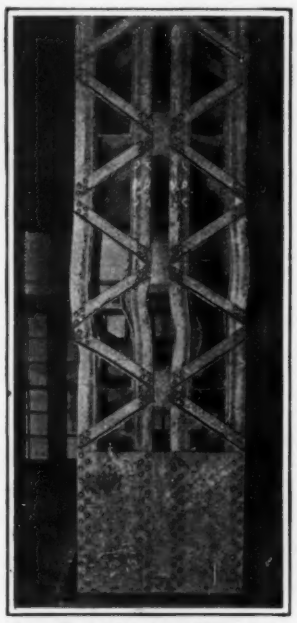
"Ten Million Pounds"

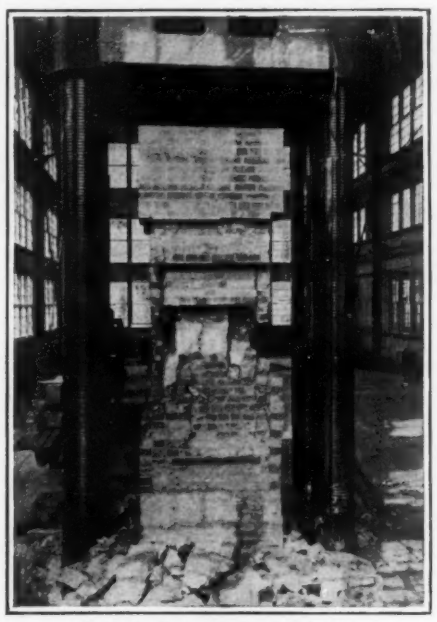
By C. H. Claudy

"GREAT pressure is being brought to bear on Mr. So-and-so to force him to yield, etc."

Whoever invented that phrase must have seen the testing engine of the Bureau of Standards, at Pittsburgh, in action. For no other government engine is capable of squeezing material with quite so strenous a grip as this huge device. The testing engine at Washington can exert a pressure of three million pounds, and a pull of approximately half as much, but the Olson machine at Pittsburgh can affect a total stress of ten millions of pounds, or five thousand short tons upon any object not too large to be placed between the weighing platform below, and the movable head, above.



The effect of tremendous pressure on a steel girder



Putting the screws on a brick column

Constructed, as are practically all such devices, upon the hydrostatic press principle, the Olson machine differs from the great machine at Washington in that it exerts its stress vertically instead of horizontally, and is not adapted to pulling materials apart, but is only able to put them under pressure. It is huge in size, being calculated to test pillars, beams or girders 25 feet in length and with a least cross section dimension of six feet.

It consists essentially of four immense steel columns, 13½ inches in diameter, provided with huge screw threads, a moveable head or platform traveling up and down upon these four pillars, and a pressure or weighing platform below. Connected to the latter by suitable piping is the weighing mechanism, which shows the amount of pressure being applied, and the oil pumps which, through the 50-inch pressure piston beneath the pressure platform, exert the pressure on whatever is clamped between these mighty jaws.

The upper head of the machine is adjusted by the operation of a 15-horse-power motor, which turns four large nuts about the stationary screws, thus elevating or depressing the head. It is at first glance surprising that 15-horse-power motor is a sufficient force to operate this engine to its full load capacity, a surprise which disappears on learning that the maximum speed of the main or straining piston is ½ inch per minute, and the minimum about $\frac{1}{60}$ inch per minute. The rate of pressure application may be varied by altering either the length of pump stroke, the rate of oil inlet, or the motor speed. In practice, neither the maximum nor the minimum speeds of pressure application are often used.

The lower or weighing or strain platform, which has a maximum travel of two feet, rests on a spherical bearing five feet radius, in order to permit a ready bringing into alinement of the axis of the specimen to be tested and the axis of the 50-inch pressure plunger or piston. The upper head is also adjustable to insure perfect parallelism between its face and the upper face or end of the material being tested.

The machine in use is a veritable wizard in discovering unknown facts about structural materials of all kinds, and in answering otherwise unsolvable questions. It is able to show the elasticity of a material, or the variations in elasticity of one material assembled in structures of different constructions, as for instance, the effect which various "bonds" have on the elasticity or the strength of a brick column. It will show, with the aid of accumulative pressures applied in regular amounts, the compressibility of any kind of material, the point at which it begins to fail and disintegrate. Because the enormous pressure is applied so slowly, so gently, yet so inexorably, exactly as pressure on a brick pier in a building is applied, the results obtained are sufficiently near those to be had in actual service to be so considered in formulating specifications for future construction.

Practically no material or structure design used in building of any kind can withstand the pressure applied in the Olson machine. Concrete columns, cast iron columns of great thickness, steel girders, cement slabs, hollow tiles, walls of all sorts of construction, lattice steel work, reinforced concrete, all yield themselves to the persuasion of so tremendous a strain. Meanwhile, the operator in charge, with his note book and pencil, his eye to a gage showing variations in dimension as more and more pressure is applied, makes the material or the structure tell its own story that builders may know whether they are building well or ill, of good material or poor.

It is essential that all possible facts regarding a material, or a particular structure, be at hand before drawing conclusions, because of the presence of variable factors, which may differ at different times without visible evidence. Thus, in testing a brick pier, for instance, to see what strain it can stand without failing, and what variations in size result from any compression up to the failure point, it is essential to know first, where the bricks come from. Brick from Pittsburgh may be entirely different in strength from brick from Chicago or Birmingham, and no conclusion could be accepted as to brick in general from tests made of bricks from a specific locality, even if all bricks were of the same size, shape and weight. Is the brick vitrified, burned, or common baked brick? What is its absorption? What sort of mortar is used in building the pillar to be tested? Of what kind of cement is it made, what sort of sand is used, what variety of lime? How many courses are laid in the test specimen, what sort of bond are they laid in, what size joints were laid and how thick is the mortar between courses, and how old is the specimen?

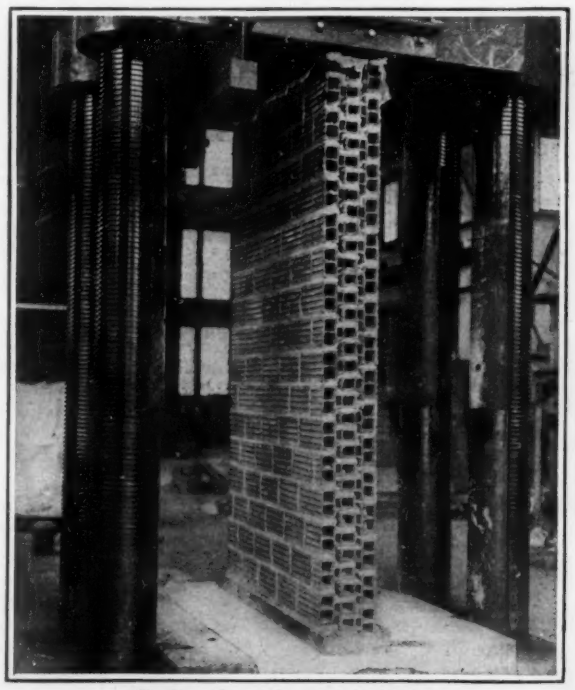
Such questions have a very important bearing on the tabulation of results and are cited here to show that use of the machine is hardly as simple as it appears. The scientist in charge of an investigation does not merely build a brick pier, put it between the jaws, turn on the pump until the specimen breaks down and then announce "a brick pier 10 inches high and 30 inches square can support a load of 1,500,000 pounds."

The results of a series of tests, such as on brick piers, are entirely too long and highly technical, yielding results of interest only to the civil engineer and the builder, to give in detail here. They include not only the conclusions reached from many different tests as to failing points, total load, elastic limits and the like, but stress-strain curves, deformations, lateral strains, etc., etc., etc.

In testing new forms of building material, such an engine is invaluable. Certain varieties of hollow tile, invented by tile manufacturers, or constructed according to a new formula for clay or new process of firing, can be made to tell their usefulness and power to withstand strain in a machine of this kind as nowhere else save in a building—and testing new materials in a building is not very profitable if they happen to fail.

Of course, many laboratories have testing engines powerful enough to make

(Concluded on page 445)



Testing the resistance of a hollow tile wall

Finding the weak spots in a tile-and-brick construction

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The object of this journal is to record accurately and lucidly the latest scientific, mechanical and industrial news of the day. As a weekly journal, it is in a position to announce interesting developments before they are published elsewhere.

The Editor is glad to have submitted to him timely articles suitable for these columns, especially when such articles are accompanied by photographs.

The Russian Front; A German Sanitarium

IT is not unlikely that many people have wondered why it is that the Allied High Command, to say nothing of the expert military writers, keep on repeating that the great war will be won on the western front, when all the while the advances secured in the British and French attacks are relatively so slight as to mean not much more than a slight thickening of the line which the civilian traced upon his map, some three years ago, to indicate the western fighting front.

These doubters (and thanks to enemy propaganda, their name is legion), should remember that the line which they draw with pen and ink upon the map is reproduced upon the fields of France and Flanders in a fierce white flame—a seven-times heated furnace—in which the very flower of the German army is being constantly shrivelled up like a scroll. Not in any one of the historic wars of which there is reliable record, have the regiments and divisions of a great army been decimated and redecimated on such a tragic scale as that which is now witnessed in France and Flanders.

The rate of these losses is well known; for the determination of the numbers and composition of the enemy's troops is carried on by scientific methods of observation and research which yield remarkably accurate results. The Commander-in-Chief of an army is not only supplied with wonderfully detailed knowledge of the number of divisions maintained by the enemy in the field, but he knows where those divisions are, in what engagements they take part and the extent of their losses. Thus, a division which has been so badly cut up in an offensive as to be no longer available for front-line fighting, will be withdrawn to some base, thoroughly rested up, and its numbers brought up again to full strength by drawing on the reserves back of the line. It will then be sent forward to the same or to some other front; and this process may be repeated several times in the course of one of the long drawn-out battles which are characteristic of the present war.

Now for some time since the Russian Revolution (that delirium which has since become a disaster), Germany, whose knowledge of conditions in the Russian Army was probably more intimate than that of the Russian High Command itself, has been using the Russian front as a kind of gigantic sanitarium for the rest and convalescence of those wounded soldiers who had been discharged from the hospitals, but were not sufficiently recovered to endure the frightful ordeal of the Allied attack on the western front.

Austria was following the same general policy. Associated with these convalescent troops were the semi-efficient old gentlemen of the Landsturm. How thinly the Russian line was held and with what an inferior quality of troops, is suggested by the fact that, even after the Russian debacle had taken place, Brussiloff was able to launch an offensive that easily brushed aside the enemy lines and resulted in a huge bag of prisoners.

In the intervening months since the Revolution, it is probable that the Germans have maintained only the semblance of a fighting line on the Russian front. Long before the outside world became aware of it, Germany knew to what an utter depth of degradation the Russian military morale had fallen—they knew long before anyone else that the Russian Army as a military force had ceased to exist.

Therefore, we are inclined to believe that such German forces as were sent into Austria must have come not from the Russian but from the French front. Everything that was of sufficient quality to face the supreme trial of British and French attack, in the West, had doubtless been dispatched from Russia long before the great offensive was launched on the Isonzo. This being the case, it is safe to assume that the tide of German invasion is now at its full height. We may feel assured that every man and every gun that can be spared for this great Italian forlorn hope—it is nothing more—is now ranged along the Piave and in the valleys that open down to the Italian plains.

Italy, fighting with a courage and persistency worthy of her finest traditions, seems to be holding the enemy in check; and, meanwhile, the dispatches tell us that the French and British armies are pouring in through the Alps and over the French-Italian railways, and hastening to the support of the reformed and reconstituted Italian armies. It is too early yet to say that the crisis is past; but this much is certain, that, within the month, we shall know whether Germany is to overrun another of the countries of her enemies, or whether this venture, so far as any military decision is concerned, is to prove utterly abortive. Already it begins to look as though the Italian campaign will have to be written off as one more of those utterly fruitless expenditures of several hundred thousand troops, that can ill be spared from the dwindling man-power of the German and Austrian armies.

After Coöperation, What?

FOR several weeks, on this and other pages, we have been bearing down hard upon the lessons in coöperation which the war holds out to us. We have tried to show how absolutely clear it is, in the light of the past three years' experience, that the only way in which a thing can be done to the best effect is for all concerned in its doing to get behind and push in unison. We have pointed out that this applies not only to the conduct of a war by a group of nations, but that it holds equally within a nation, between the units of the commercial and industrial structure, and regardless of whether the object in view be one of war or of peace. In the whole catalogue of human activities there is no place where the principle of coöperation may not be applied with advantage.

But coöperation alone is not enough. Britain and France and Italy and America must do more than pool their resources and their efforts for the defeat of the Hun; our railroads must have more than the willingness to work together before they can give us a maximum of transportation; our automobile makers must do more than coöperate in the manufacture of Liberty Motors and Liberty Trucks. Each of the Allies must furnish, not that equipment which it would prefer to furnish, but that which it is best and the others least equipped to furnish; the quota of man power must be apportioned in the same way; and above all a rational plan of campaign must be mapped out and adhered to—it must be definitely and irrevocably established what is to be attempted, and where, and how, and why; it must be clearly understood what is not to be done, and why not. In the same way the railroads and the automobile factories must divide their work to the best advantage, avoiding omissions and duplications, each attacking its allotted share earnestly whether or no that be the share which it would best like to have allotted to it, and being above all careful not to be diverted into any profitless side enterprises.

In other words, coöperation is but an empty word if intelligent direction be lacking. The ridiculous Gallipoli expedition was undertaken in the name of coöperation between England and Russia; it stands as a monument to lack of proper coördination. The Kut disaster is another piece off the same bolt; adequate coördination would have vetoed this before it was started. The experiences of the Allies and of the Teutons since the war began but add to the volume of evidence previously on hand to show that intelligent human effort is possible under one condition, and only one—with centralization of authority and of responsibility, as well as of resources.

If we will but accept this fact, we may see in the war a new significance, which may perhaps have escaped many of us. The philosophers, in treating of forms of government, have always recognized two distinct alternatives. The powers and responsibilities which are implied in the very term may be centralized, or they may be distributed. The objection to centralization is the possibility of abuse; that to decentralization we know but too well. When our Colonial statesmen met to draw up the Constitution under which we live, they had before them an outstanding example of abuse of power, and quite naturally were animated mainly by a desire to steer clear of this possibility. Accordingly they exerted the greatest ingenuity to devise a complicated machinery of governmental checks and balances, in which nobody should have power enough to abuse. For a century we lived under the system which was thus brought forth; but eventually we found that with no power there is no responsibility, and that when things go wrong there is then no apparent cause or remedy.

So for the past 50 years we have been gravitating away from this idea of checks and balances, and moving toward centralization of power and of the accompanying responsibility. The short ballot has come in, and the Commission government for cities; our executives, President and Governors alike, have been gradually taking over more and more of the functions formerly exercised by legislature or judiciary. But when we thus modify the underlying principle of our government, we submit to the danger of abuse of power which our forefathers feared. A question of the hour is then whether we can continue to delegate great powers and responsibilities as we are doing, and yet retain sufficient hold over those in high places to prevent abuses.

History tells us that under similar circumstances the Romans, even the Greeks, were not so capable. We have before our eyes grim evidence that the Germans of today are not. The very unscrupulousness of those to whom they have delegated power has driven us into a conflict, which it now seems that the German people insist is being make against them as well as against their rulers. And—strange irony of it all—we are forced to fight fire with fire, to promote the efficiency of our war-making by borrowing the procedures of centralization which the enemy has developed so highly, and employing them against him. Then, when we are through with the war, and the enemy stands beaten, as of course he must eventually, what shall we do with our newly won forms of centralization?

Centralization, we easily see, is the greatest single agent of efficiency which man possesses. But its abuse started this war. We expect, however, by its use, ultimately to stop the war. What will we then do with centralization? Will we conclude that its obvious advantages outweigh its equally obvious dangers, and retain it; or will we take the opposite point of view and reject it? Or, finally, will we endeavor to do what America has unconsciously been doing for 20 years past—steer a middle course, taking as much advantage of the possibilities of centralized industries and government as we can, without bringing centralization to a point where it becomes a menace? For the answer to these questions we must wait upon the future; but we should at least perceive that in them is bound up the whole course of the world after the war, and that according as they are answered, so will the historian of a thousand years hence estimate the war as of net benefit or of net loss to the race.

Fairy Rings

THE circular growths of grass and other plants known as "fairy rings" figure rather notably in folklore, but scientific information in regard to them is scarce in the ordinary reference books. Yet they have an extensive literature of their own, scattered through the scientific journals. Much of this literature is summarized in a long memoir by Messrs. H. L. Shantz and R. L. Piemeisel, setting forth investigations conducted by themselves in Colorado from 1907 to 1916, and published in the *Journal of Agricultural Research* for October 29th, 1917. The memoir deals only with the rings caused by fleshy fungi. The subject possesses more than a curious interest, since these rings may become so abundant locally as to affect materially the crop yields of fields, while in lawns they produce unsightly bare spots or dark green areas, so that their eradication is a practical desideratum.

The earliest serious attempt to trace the origin of fairy rings to other than supernatural causes appears to have been that of Richard Bradley, who, in 1717, suggested that they might be the work of ants or snails; though at an even earlier period an impression prevailed that the rings might be caused by lightning. A considerable amount of information concerning early studies of this subject and also concerning superstitions connected with the rings will be found in Hazlitt's edition of Brand's "Popular Antiquities" ("Faiths and Folklore," London, 1905), a work not cited by the authors of the above-mentioned memoir.

William Withering, in 1796, first definitely assigned the production of rings to a fungus, and this opinion was confirmed a few years later by Wollaston, who found that several species of fungus were capable of producing rings. Down to the present time more than fifty species have been reported as causes of fairy rings.

A fairy ring may consist of a more or less circular zone of bare ground, or one of luxuriant vegetation, or both. Other types are also found. The rings occur mostly in grass land, but are sometimes found in forests. The initial phenomenon is the germination of a fungus at a particular point, from which, as a center, a circular fungus colony gradually spreads outward. "Investigators differ as to the exact cause of this outward growth, some attributing it to the exhaustion of the nutrient materials of the soil, others attributing the cause partially to the fact that the active mycelium occurs only on the outside of the ring, and that the portion of the mycelium on the inside is already old or dying." The stimulation of vegetation appears to be due to chemical changes in the soil resulting in some cases from the growth and in others from the decay of the fungus.

The rate of growth of the rings varies for different species and with different weather and soil conditions, ranging from a few inches to a foot or more per annum. The largest rings are six or seven hundred feet in diameter and probably represent several centuries of growth.

Methods recommended for the eradication of fairy rings include applications of sulfates of copper and iron, or repeated stirring of the soil, especially during periods of dry weather.

Astronomy

The Total Solar Eclipse of June 8.—This will be the great astronomical event of 1918, and preparations for observing it are well under way. The most useful small-scale charts of the eclipse are those published by William F. Rigge in *Popular Astronomy*. November, 1917. The same number of that journal contains detailed data showing the latitudes and longitudes of points on the central line and limiting lines of the track of totality; also the altitude and azimuth of the sun, at time of totality, at points along the central line. The latter information will be especially useful to persons planning to observe in mountainous country, with a more or less obstructed horizon. The principal large-scale map of the eclipse is that contained in the pamphlet recently published by the Naval Observatory, Washington, D. C., as a supplement to the American Ephemeris for 1918.

Novæ in Spiral Nebulæ.—It is announced from Mt. Wilson that a new star of about the 14th magnitude has appeared in the spiral nebulæ N. G. C. 6946. It is 105 sec. south and 37 sec. west of the nucleus of the spiral. In connection with this discovery, Dr. H. D. Curtis points out that this is the sixth time the appearance of a nova has been reported in a spiral nebula. In August, 1885, a new star appeared in the Great Nebula of Andromeda only a few seconds of arc from the nucleus. After attaining the 7th magnitude it faded rapidly and is now invisible. The nova known as Z Centauri appeared only 28 seconds from the nucleus of the spiral N. G. C. 5253. In three other cases the former appearance of stars, now invisible, in spiral nebulæ has been ascertained from an examination of photographic plates. The latest made its appearance in N. G. C. 4527 some time between January 13th and March 20th, 1915, and is found on plates made at several observatories. The number of these cases indicates that the new stars in question were actually in the nebulæ, and not merely in a line with it as seen from our system.

Messier's Catalog of Nebulæ.—The catalog of nebulæ and star clusters compiled by Messier, the French comet-hunter, and published in the *Connaissance des Temps* in 1784, although it contained only 103 of the brighter objects of these classes and has long since been made superfluous by the great General Catalog of Herschel (commonly known as the "G. C.") and the greater New General Catalog of Dreyer (known as the "N. G. C."), is far from obsolete at the present day. It is still very common to find nebulæ and clusters referred by an "M." number in books and papers on astronomy. In the *Publications* of the Astronomical Society of the Pacific, Harlow Shapley and Helen Davis have just presented a convenient table giving the positions, N. G. C. numbers, and descriptions of all the objects in Messier's list. This is the first complete and concise list of its kind, and was compiled from many sources. The identification of M. 102 is still doubtful. Appended to this table is another, by H. D. Curtis, giving the N. G. C. numbers corresponding to the numbers in the G. C. Dr. Curtis refers to the "exasperating and time-consuming" necessity which, in the absence of such tables, astronomers have been under of identifying the objects given in the older lists, and recommends the exclusive use of the N. G. C. numbers.

Occultation of a Star by Saturn's Ring.—A unique observation made independently by two English observers, Messrs. Ainslie and Knight, has been reported to the British Astronomical Association. On Feb. 9, 1917, a seventh magnitude star was seen to pass behind the outer ring of Saturn into the Cassini division (the space between the outer and middle rings), and after grazing the second ring and moving for some time along the Cassini division, to traverse again the outer ring, and finally emerge from its outer edge. In other words, the star was occulted by a part of Saturn's ring system. The interesting feature of the observation is that the star was plainly visible at all times while behind the ring, though its brightness was diminished to about one-fourth. This fact indicates that the particles composing the ring must be of quite small size. Dr. Crommelin, in commenting on the observation, suggests that the angular diameter of the stellar disk would be of the order of one ten-thousandth of a second, and this means that an object less than half a mile in diameter, at the distance of Saturn, would hide the star while passing over it. He sees here "further proof of Maxwell's prediction that the ring is composed of very minute particles, probably not more than 200 yards in diameter." Another interesting fact was that the star was seen to brighten for a few seconds at two places in its path across the ring. These brightenings evidently coincided with its passage across Encke's division and another division, exterior to Encke's and not usually visible. It will be recalled that Prof. Lowell believed there were six or eight divisions in the outer ring. The Rev. T. E. R. Phillips suggests that the number of divisons between these swarms of moving particles may vary from time to time in consequence of perturbations.

Science

The Forests of Porto Rico.—According to a publication of the U. S. Forest Service the once immense virgin forests of Porto Rico have been laid waste to a deplorable extent. The total wooded area now amounts to about twenty per cent of the area of the island, but not more than two-fifths of this is now under forest capable of yielding a wood product other than charcoal and fuel wood. The area of high forest is hardly two per cent of the total land area. Reforesting is a great need of the country, both for the sake of the water supply and to provide timber and fuel.

The Midwife Problem in the South.—The town of Rocky Mount, N. C., has set a good example to other southern communities by establishing a school for midwives and requiring them to pass a satisfactory examination before receiving permits to practice their occupation. Instruction is free and is given by the city health officer. Although the school was recently started a falling-off in the infant death rate is already noted; also an increase in the recorded birth rate, due to complete birth registration. In North Carolina almost twice as many negro babies as white babies die during their first week, owing largely to the fact that ignorant midwives are so generally employed by the negroes in place of physicians. Mortality among mothers is also largely attributable to the midwife.

The Name "Haiti."—American consul Arthur McLean, stationed at Puerto Plata, Dominican Republic, raises a protest against the common practice of applying the name "Haiti" to the whole island in which the republic of Haiti and the Dominican Republic are situated, and he makes the decidedly impracticable suggestion that the island should be referred to as Haiti-Santo Domingo. As a matter of fact, this island has borne several names. Columbus named it Hispañola (Hispaniola). Later the whole island was known as Santo Domingo. Nowadays, however, the name Haiti is almost universal in geographical literature, and there is no likelihood that it will be abandoned. Certainly "Haiti-Santo Domingo" is altogether too long a name for this busy age of ours.

Uniform Scientific Symbols.—In a letter to *Science*, Dr. Otto Klotz, director of the Dominion Observatory at Ottawa, urges the importance of securing a greater degree of uniformity than now exists in the mathematical and other symbols used in the various sciences. This is, of course, a long mooted question. A committee of the American Association for the Advancement of Science took the matter in hand some years ago, but its efforts were frustrated by inability to secure international coöperation. Dr. Klotz seems to think that American scientists should not wait for international agreement, but should standardize symbols for their own use. In normal times we would consider this a most unfortunate suggestion, but it is obviously the only scheme that is feasible at present. Dr. Klotz proposes that tables of symbols for the various sciences be prepared by the Carnegie Institution of Washington and distributed gratis to all the scientific men of America.

New Uses for Fur Seals.—The latest project of the U. S. Bureau of Fisheries for increasing the national food supply is the canning and corning of seal meat. The meat of the seal, fresh, salted and smoked, is a regular article of diet among the natives of the Pribilof Islands. The shoulders are said to be especially palatable, and, when properly cooked, to resemble swan breast in flavor and appearance. This dish is regularly served at the mess of the government employees on St. Paul and St. George Islands. A small experimental canning outfit is to be installed in the islands. It is also proposed to utilize the bones of the seal in making fertilizer; to obtain oil for dressing skins from the surplus blubber; to make leather from the throats or gullets; and possibly to use the intestines for casings, and various glands for medicinal or food extracts. The prospective resumption of commercial sealing at an early date will yield a great number of seal carcasses for these various purposes.

Weekly Death Statistics of American Cities.—A weekly circular giving the mortality statistics of the principal cities of the United States is now issued regularly by the U. S. Census Bureau. It gives the total number of deaths reported (stillbirths excluded), the death rate per thousand, number of deaths of infants under one year of age, and the proportion of infant deaths to total deaths. The cities for which data are given include one-fifth the population of the country. Thus the circular is a fairly accurate index to the state of the nation's health. Its uses are manifold. It will show local health authorities how their home towns stand in comparison with other towns in respect to mortality and when a town has a bad record the publicity given to the fact should spur the authorities to seek the cause and remove it. Insurance companies will find the reports of interest. The circular is issued in Washington every Tuesday, and is distributed free of charge.

Engineering

Our Largest Shipbuilding Plant.—The Government has taken over the Risdon Iron Works adjoining the Union Iron Works at San Francisco. The former will be operated under the same management as the latter in order to carry out Government contracts. By this addition to the Union Iron Works it is claimed that San Francisco will have the largest shipbuilding plant in the country. The Risdon Iron Works cover 30 acres, and have eight shipbuilding slips.

Proposed New East River Bridge.—New York City is considering the advisability of building a new bridge across the East River. This structure, according to the plans, will run across the main channel at Hell Gate to Ward's Island and then across Little Hell Gate Channel to Randall's Island. Here it will branch, one arm crossing the Harlem River to Manhattan at 125th Street, and the other the Bronx River at Southern Boulevard. The main span will be of cantilever construction. The branch running from Randall's Island to Manhattan will have a lift span. The bridge will provide for vehicular and pedestrian travel and for surface and rapid transit railway traffic. Vehicular communication with Randall's Island and Ward's Island will be provided by inclines.

Converting Superfluous Electric Energy into Steam.—In Alpine regions of Europe where hydro-electric power is abundant, efforts have been made to store the superfluous electric energy of power plants. Boilers arranged to use electric heat have been employed in Switzerland and in Italy. In the latter country, the ohmic resistance of the water to the passage of electric current has been utilized. In a boiler of this type, invented by Colonel Revel of the Italian Army, alternating current of from 200 to 3,600 volts is turned into the boiler. The production of steam is regulated automatically and continuously, so that it requires no attention. The steam generator works at any pressure up to 14 atmospheres, and may be connected to the ordinary steam boilers at any time.

Extending the Catskill Water Supply Project.—Recently, New York celebrated, officially, the opening of the Catskill Water Supply System, and at the time it was announced that work would soon begin on the extension of this system to include the Schoharie watershed. This extension will involve the construction of an 18-mile tunnel through the Shandaken Mountains. Since the recent election, which will bring a new administration into power at the first of the year, there has been an effort to block this extension under the plea that the cost of construction work at the present time is very high; and that it will be far more economical to wait a few years until prices of materials have been reduced and labor is more plentiful. While this argument may seem very plausible, it should not be forgotten that there is an excellent organization for building the extension, in the existing staff of engineers. If the Schoharie watershed is to be abandoned, this organization must be dispersed. It is no simple matter to build up an organization such as this which will work smoothly and efficiently. The present staff is an asset that the city cannot afford to throw away without giving the matter serious consideration.

A Thousand Miles of Railway Through Waterless Country.—The longest tangent in the world, 330 miles without the slightest variation from a straight line, occurs on the railway linking Western Australia to the eastern States, which was formally opened on November 12th. In the 1,052 miles of line between Port Augusta and Kalgoorlie there is not a single tunnel and very few cuts, while at only a few places on the eastern section is the ruling grade of one in eighty approached. The 330-mile straight occurs in the great limestone region of the Mullabor Plain which the line traverses for over five hundred miles. This is a desolate waste in which there are no hills, no valleys, no rivers, no trees, and no water. When the line was begun in 1912 the country along four-fifths of the route had not a single inhabitant except a few wandering aboriginals, and absolutely no permanent surface water. Indeed water has been the one great difficulty of the line. At a few points reservoirs have proved successful but for the most part the only supply available has been drawn from wells and bores. This water contains such a high proportion of solid matter and acids that it is very unsuitable for locomotive use, rendering special devices necessary, while in places it is salt and condensors have had to be erected. At one period during construction water for all purposes had to be carried over three hundred miles by train on the western section. The line gives the first communication by land between the two halves of Australia and opens up a quarter of a million square miles now unoccupied. In spite of the scanty rainfall, averaging well under ten inches a year, much of this country is well grassed and grows salt bush and other edible plants which would carry large numbers of sheep and cattle if water can be provided. The cost of the line has been about $40,000,000.

The Submarine Problem—XX (Conclusion)

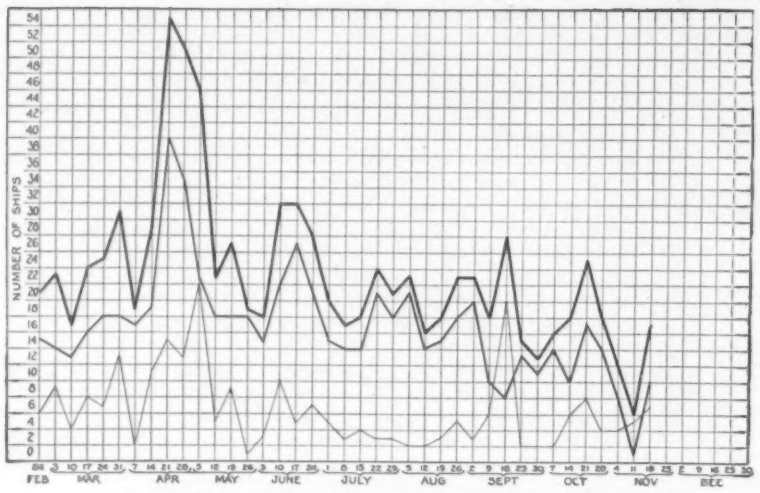
Past Results and the Promise of the Future

By J. Bernard Walker

DURING the week ending April 21st, 1917, the German U-boats sank 40 merchantships of over 1,600 tons and 15 of less than 1,600 tons—a total of 55 ships. During the week ending November 11th, 1917, she sank one ship of over 1,600 tons and five below 1,600 tons—a total of six ships.

When the submarine crisis was at its height, we commenced to publish a series of articles on the submarine problem, of which the p esent article is the last. The object of this series was to lay before the public the fundamental elements of this great problem, and assist the thousand-and-one inventors who were seeking for its solution, by suggesting the lines of endeavor along which the greatest promise of success was to be found.

When the British Government announced recently that, in one week, only one ship of ocean-going size had been sunk, we felt satisfied that this astonishing drop in casualties must be due largely to fortuitous circumstances; and to fortuitous circumstances also must be attributed, we believe, the astonishing "bag" of no less than five U-boats in one day, as publicly announced the following week by Lloyd George. At the same time, after making all allowances for the element of chance, it takes but a single glance at the accompanying chart showing the week-by-week sinkings of British ships, to make even the most sad-eyed pessimist realize that the Allied navies have the U-boat menace by the throat, and that they are slowly strangling it to the point, if not of extinction, at least of exhaustion.



The light line, ships below 1,600 tons; medium line, ships above 1,600 tons; heavy line, total ship losses

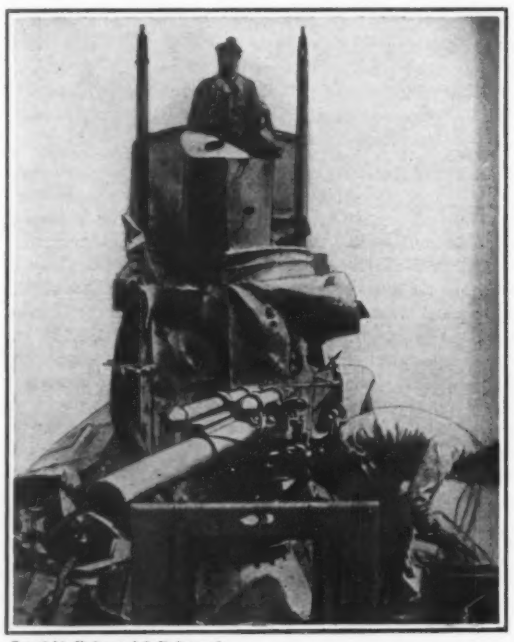
Decline of the U-boat campaign

But let it be clearly understood that this stage has by no means been reached as yet. The U-boat menace is still most serious, and the call is insistent for placing every anti-U-boat craft and installing the very best anti-U-boat weapons in the zone of operations, and bending every effort in our ship-and-engine-building yards and factories, not only to replace the tonnage which has been lost, but to offset those losses which will inevitably occur, even though in diminishing amount, for many a long month to come.

It is the purpose of the present article to make a very brief résumé of what has been done in the offensive-defensive war against German piracy, and to point out the devices and methods which are today most successful and the lines of investigation which promise the best results in the future.

When the U-boat campaign was at the height of its success, and immediate and urgent measures were needed, it was believed that the most effective plan would be to blockade the submarines within their individual bases, or, failing that, restrict their operations to a certain well-defined area. Hence the proposal to build nets of greater or less magnitude, ranging from those stretched across the separate U-boat exits to the audacious proposal to build a net 250 miles in length across the North Sea. Strategically considered, these netting propositions were perfectly sound; the objections to them were purely of a mechanical and practical character. Great Britain, both in the English Channel and at the northerly entrance to the Irish Sea, had found that the mass of seaweed carried in the swiftly-running tides loaded up the nets until they bellied out like the close-reefed topsails of a frigate driving before a gale of wind; and the consensus of opinion among practical seamen ranged all the way from the belief that, if the tackle were made heavy enough a net could be built and held in place even in the North Sea, down to the conviction that no net whatsoever could be permanently held in place in the location and on the scale proposed. Meanwhile, the defensive and offensive measures employed against the U-boat have been getting in their good work. From forty to fifty per cent of the output of the German submarine builders has been captured or sunk; and, today, the point has been reached where the number of U-boats that sets out at any one time from the various bases is so small as to render the present methods of attack and defense from the surface of the sea a more paying proposition than would be an attempt, on a gigantic scale, to attack them below the surface of the sea by a wholesale system of netting. Moreover, the Germans are credited with having devised a cutting device which will carry them through the heaviest nets that can be employed.

An alternative to the nets is the placing of mine fields at the exits in such numbers, and with the successive lines of mines so disposed in the vertical plane, that no U-boat can pass through without imminent risk of contact and destruction. The British Admiralty has made announcement from time to time of the placing of such mine fields, and there is little doubt that these have taken their toll of the U-boats.



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This shows what shell-fire did to a German submarine

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Looking astern from an American destroyer as she steams into a head sea

Naval officers will feel a justifiable satisfaction in the fact that, even before this war commenced and therefore before any practical experience had been gained in the matter, they regarded the destroyer as the best weapon of defense against the U-boat, and that, today, after the millions of money that have been spent and the untold amount of thought and skill that has been given to the problem, the destroyer has emerged as the most effective answer to the submarine.

Fast, quick on the helm, carrying a heavy battery of guns having great rapidity of fire, and, armed in these later days with the deadly depth-bomb, the destroyer has become a veritable terror to the undersea boat.

In the earlier stages of the campaign, when the U-boat, because of its limited range, carried out its depredations within circumscribed fields, the Allied navies sought to cover the seas with such a swarm of anti-submarine craft as to make it perilous for the U-boat to show itself by day upon the surface. But when the later U-boats, of larger radius of action, moved out into the Atlantic it became impossible to continue this scattered patrol; and instead of permitting the merchantship to run through the danger zone unattended and "on its own" as it were, it was determined to resort to the time-honored convoy system, in which the ships are assembled in groups and convoyed by an encircling screen of warships. This method is now being followed in transporting our troops to Europe, and the measure of its success is shown by the fact that for several months we have been sending a steady stream of men to the battlefield, without the loss of a single loaded ship.

The advantage of the convoy system consists in this: that before the U-boat can get at its victim—the merchantship, it must encounter its enemy—the warship. And the warship, in the shape of a group of destroyers armed with the rapid-fire gun and the depth-bomb, is just the very thing that the U-boat is most anxious to avoid.

During a discussion of the U-boat problem in the early days of the crisis, a British naval officer said to us: "If you will only provide the destroyer with some sure means of finding and following up the U-boat, we will get him every time." And undoubtedly in this direction lies the promise of the future. If a way can be found to provide the destroyer with acute mechanical ears the submarine will be so thoroughly mastered, that the German Admiralty will call home its U-boats and abandon the campaign, as being no longer worth what it costs in time, materials, men and money.

As we have shown in this series of articles, something has been accomplished in this field; although the results have not been very encouraging. However, we must not forget that this is a comparatively new field of investigation whose possibilities have by no means been exhausted—in fact, they have scarcely been touched. There is one device of French origin, of which we can say no more at the present time than that it is of the selective type; and this, if its early promise be fulfilled, may provide the destroyer with ears which will be deaf to any sounds but those of the prey for which it is hunting. Herein lies the promise of the future. We commend this problem to the inventor as the one which contains more possibilities of large and decisive results than any in the whole field of anti-U-boat operations.

Among the various devices described and illustrated in this submarine series which have been rejected as not being practicable, we must mention the towing of nets, steel plates, and similar protective devices with the object of intercepting and detonating the torpedo before it reaches the ship. The objections to these are, first, the difficulty of holding such systems in place in heavy weather; and, secondly, the fact that they cut down the speed by one-half.

As regards those forms of protection which are interior to the ship itself—such as longitudinal bulkheads and the provision of wide cellular spaces between the outside skin and the interior cargo-carrying

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The "U-65," one of the large German submarines with two guns permanently mounted on deck

hull, it may be said that the protective value of such construction is fully realized by the technical men who are responsible for the construction of our new emergency cargo and transport fleet. For our part, we consider that, as between the fully compartmented and the ordinary standard type of freight ship, a thoroughly effective and not very costly method of protection could be found by simply doubling the number of watertight bulkheads, carrying them all up to a watertight deck, and prohibiting the cutting of any connecting doorways below the waterline. This would, of course, increase the cost and add also to the time of loading and unloading; but, after the war, these ships could be brought back to standard conditions for convenience of loading and handling freight, by cutting out the alternate bulkheads.

The reason why such construction has not been embodied at the present time—that is, not in the first batch of ships—is that torpedo-proof ships would take very much longer to build. The aim of the Emergency Fleet Corporation is to get afloat at once a large tonnage. The same considerations of urgency have led to the adoption of the moderate speed of 10 to 12 knots. It would take probably twice as long to build torpedo-proof ships having, say, 16 knots speed as it will to build the 11-knot, standard type freight ships, which constitute the bulk of the construction that is being rushed through at our yards. Ultimately, however, when the pressing needs of the hour have been met, and, provided that the U-boat menace has not been by that time removed, it is probable that anti-torpedo construction and greater engine power will be embodied in the ships that are laid down.

Meanwhile, there are many defensive measures which may be taken and should be taken by every ship that passes through the U-boat zone. The first and most important of these, of course, is a good rapid-fire gun, and in view of the heavier armament of the later U-boats, it is desirable that these should be of not less than 4-inch, and preferably of 5- or 6-inch caliber. The smoke funnels and the smoke boxes used in conjunction with the zig-zag clock, as illustrated in chapter VII of this series, have proved to be an admirable foil.

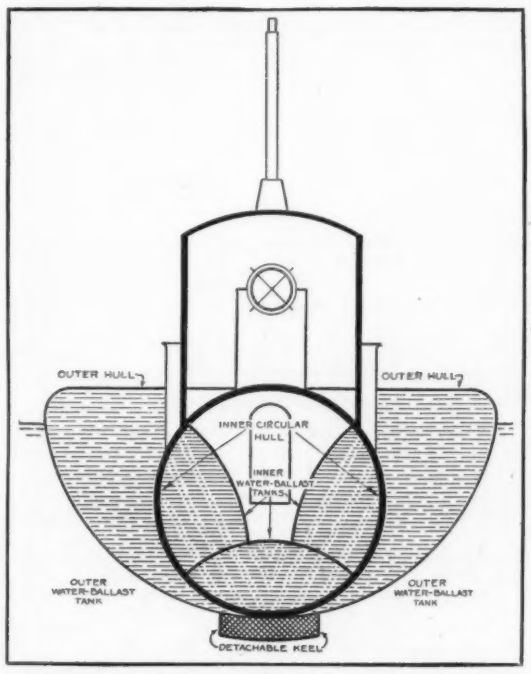
By way of showing how effective is the work of our United States destroyers and patrol boats in this amazing U-boat war, we refer our readers to the reports of our Bureau of Public Information; and we submit herewith some official descriptions of British operations, as made public by the British Admiralty and printed in some recent issues of *The Naval and Military Record*.

Torpedo that Jumped

From one of our auxiliary naval forces a torpedo was seen approaching the starboard beam. The torpedo jumped out of the water when 100 yards off, and struck the engine-room near the waterline, making a large rent and flooding several compartments. Soon afterwards a periscope was observed just before the port beam. It turned and made for the ship, but quickly disappeared as the enemy further submerged. Again it appeared, to be followed this time by a conning tower. Fire was opened, and the first shot hit the base of the conning tower and removed the two periscopes. Many hits were obtained, and the submarine quickly assumed a list to port, and several men came out of the hatch abaft the conning tower. He wallowed along for a space, stern almost sumberged, and with oil squirting from its side, and the crew came on deck and waved their hands. At this sign of surrender "Cease fire" was ordered, whereat he started to make off at a fair speed, evidently hoping to disappear in the misty weather. The men of the crew who had begun to assemble on the deck disappeared below as soon as he got headway. Fire was again opened; a loud explosion took place forward, and, falling over on his side, the enemy sank—the last thing seen being the sharp bow, end up, slowly sinking. Two survivors were picked up. Our ship made harbor.

Submarine Sinks U-boat

One of our submarines sighted an enemy submarine 1½ points on the starboard bow, so dived, but after seeing him through the periscope for a few minutes lost sight of him. Our boat came to the surface again, and about three hours later saw the enemy on the starboard beam from two to three miles away. Our boat dived to attack, but the enemy altered course, and was again lost to view. His apparent objective being conjectured, course was altered in the hope of cutting him off, and eventually he was again detected on the port bow,



Transverse section through conning tower of U-boat, showing interior (circular) pressure-resisting hull and lighter exterior hull, which is open to the sea

steering as had been surmised. Course was altered as necessary, and when as favorable a position as was thought possible was obtained a torpedo was fired. A splash was observed in line with and close to his stern, and a few seconds afterwards the enemy was seen with his stern out of water, smoke hanging round it, and the conning tower half-submerged. A minute or two later he disappeared.

Attacked by Seaplane

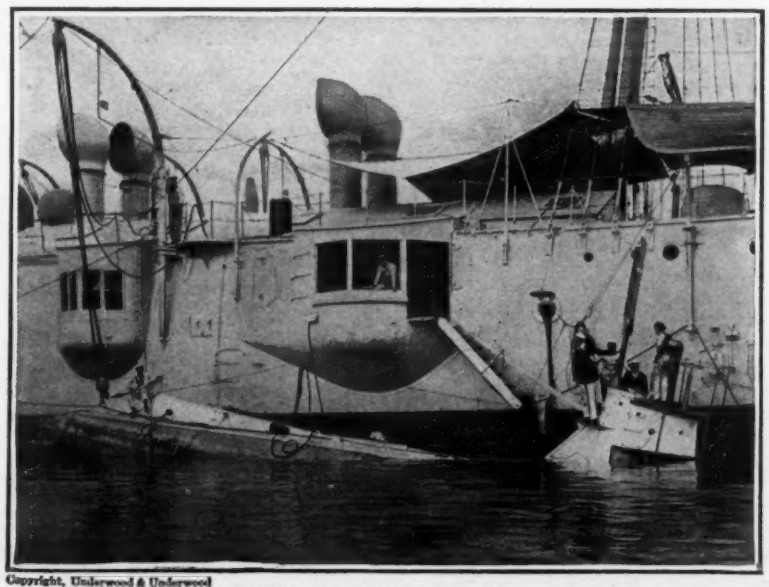
A seaplane proceeded to attack an enemy submarine which she had observed maneuvering, apparently, into position to fire a torpedo at a passing merchant ship. Before the seaplane arrived over the submarine the latter submerged, but three bombs were dropped on the position where he had disappeared from sight. In five minutes' time a large upheaval was noticed where the bombs had been dropped. This could best be compared to a huge bubble, rising some distance above the level of the sea, and distinctly visible for a minute or more. There was no further sign of the submarine.

Good Work by an Airship

One of the coastal airships, of a type familiar to visitors at seaside resorts, was recently on patrol, and sighted a steamer in distress. On descending to investigate closer, it was found that she had been torpedoed by an enemy submarine, but was capable of being towed into harbor. The airship summoned assistance by wireless, and until it arrived hovered protectingly around the crippled merchantman. No signs of her late assailant were visible, and in due course the steamer was taken in tow by tugs and headed for harbor. The aerial escort accompanied the tow, and about an hour later sighted the conning tower of a submarine about five miles southeast of the convoy, apparently maneuvering for another shot. The airship instantly signaled by wireless the position of the submarine to all men-of-war in the vicinity, and swooped down to attack. The submarine saw her coming and dived, but too late to avoid this glittering Nemesis from the skies. Two bombs were dropped simultaneously in front of the swirl of his descent. A violent explosion ensued, followed by oil and air bubbles in ominous quantities. Shortly afterwards a destroyer arrived and investigated with sweeps. The airship, returning to her base for a further supply of bombs and petrol, was overtaken by the following aerial signal: "You've undoubtedly bagged him."

Betrayed by Wake of Torpedo

On a subsequent occasion this same airship, while flying in company with a west-bound convoy of merchantmen, sighted the track of a torpedo, and a moment later observed a great column of water shoot up alongside one of the steamers. A submarine, relying on the state of the sea for concealment, had with great daring dived beneath the armed escort and torpedoed her victim under their noses. The weather at the time was bad and rapidly getting worse; the airship shot down and along the residual track of the torpedo at a speed of 90 miles an hour, and at the end of the track sighted the outline of a submerged submarine, which, her deadly work done, was leisurely proceeding westward. The airship turned and released her bombs while she hovered above the sinister, green, cigar-shaped shadow, and the explosion was followed by a vast evulsion of air and air bubbles. A calcium flare was dropped to mark the spot, and armed patrol vessels, summoned by signal, made assurance doubly sure with explosive charges. The airship returned to her base in the teeth of a head gale, and landed.



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Lifting the bow of a British submarine for inspection. The mirrors on the periscope reflect the sea and serve as effective camouflage

Big U-boat Rammed

A British "oiler" was torpedoed by a submarine at dawn in very thick weather. A patrol ship which was in company at once circled round at high speed in an endeavor to sight the enemy, who had not been seen by either ship. After proceeding for two miles on what the commanding officer of the patrol ship judged to be the most likely course for the submarine, the man-of-war returned to the "oiler," and found her still making way slowly and in no danger of sinking. When about a quarter of a mile from their charge an object was sighted through the thick mist on the starboard beam. Altering course promptly the patrol ship headed for the object at full speed, and the next moment realized that it was a large submarine on the surface. She was rammed abaft the conning tower, rolled completely over with a very violent explosion and vanished. The sea was boiling with foam, in the midst of which immense air bubbles rushed to the surface for some minutes.

The Mathematics of Winning the War

Why We Should Make the Greatest Possible Initial Effort

By Sydney Graves Koon, M.M.E.

NOW that we have entered the great European War, we should bend every effort to bring about a victorious decision *quickly*. How can this best be done? It is proposed to show here, mathematically, that it can best be done by putting forth the utmost effort of which we are capable—by leaving no stone unturned in our intensive prosecution of the war—by bringing to bear on Germany a pressure the like of which we have never exerted before—not even in the agony of the Civil War half-a-century ago.

Let us suppose as a starting point that, before the intervention of the United States, the two contending forces, everything considered, were equal, and that they must finally have fought to a draw. This is not true; but it gives us a basis from which to calculate, and the extent of its departure from the facts may easily be accounted for later. On this basis, assume that in April. 1917, the Teutonic forces may have represented a strength of 10,000 "units"; the Allied forces, likewise, 10,000 "units." These "units" are the ultimate evaluation of the entire forces engaged. They include

1. Number and physique of men;
2. Morale and morals and courage of men;
3. Intelligence and skill of officers and men;
4. Character of leadership, both local and national;
5. Strategic qualities of generals and of governments;
6. Spirit of coöperation among diverse nationalities;
7. Character and quantity of
   a. Artillery,
   b. Munitions,
   c. Aircraft,
   d. Food;
8. General transportation facilities and efficiency, both land and sea;
9. Distance from each point of contact;
10. Control of raw materials needed for (7) and (8); particularly, coal, steel and farming and grazing lands.;
11. Manufacturing genius and organization; executive ability;
12. Inventive genius and mechanical skill; engineering ability;
13. Money and credit; borrowing capacity; financial ability;
14. Temperament, resilience, patience, general adaptability and organizing and military genius of whole nations.

In short, every material, mental and moral attribute of the entire set of forces operating, at home and abroad, is included in the 10,000 units assigned arbitrarily to each side.

No man can place a definite, quantitative value on morale—on manufacturing genius—on the spirit of coöperation—on leadership. When Warren fell at Bunker Hill, it was said that his loss was equal to that of 1,000 men. Perhaps it was. But in the intricate ramifications of modern war forces, it would be futile to try to evaluate all the elements which, combined, make for success; scattered, for failure. At the same time, it must be recognized that such a value exists. It may change from day to day; but at each instant there is some quantity which represents one of two contending forces, while another quantity simultaneously represents the other. This fact is the basis of our calculation.

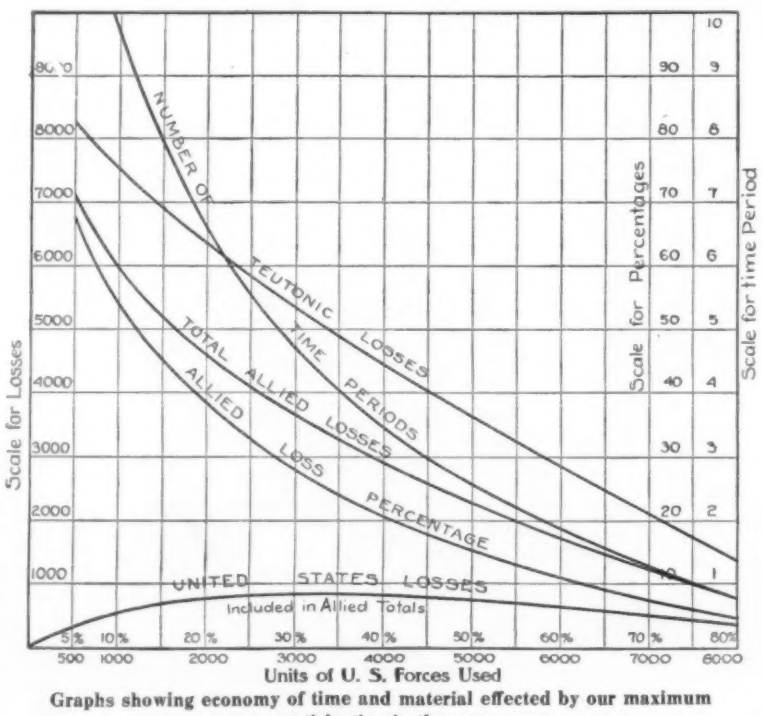
Now let us assume, which is perfectly rational, that in a certain unit of time one force (A) may damage another force (B) an amount equal to 10 per cent of A's strength; similarly, and during that same interval of time. B damages A an amount equal to 10 per cent of B's strength. Thus, a force of 1,000 would do its enemy twice as much damage, in one hour or one week, as would a force of 500. And we do not need to know what the period of time is. It varies. During the progress of a terrific bombardment and assault it is short; in the relatively inactive winter months it is long—perhaps five hundred times as long as during the most active operations. And it varies with the percentage which we assume as the loss ratio. It would approximately be twice as long, on the average, for a loss of 10 per cent as for a loss of 5 per cent; twice as long for 20 per cent as for 10 per cent.

Next, let us assume that, when the enemy's force is reduced to one-half of ours, the logic of the situation will be borne home to him; that he will see the futility of further resistance, and the war will end. We might have made this ratio one-third or two-fifths, or any other value which individual judgment might set. The general result would be the same; and, though the time required to achieve that result would vary with each new ratio chosen, our *comparative* answer would still hold. One-half seems reasonable; in any event, it may be used as a basis.

Suppose, now, the United States throw into the lists a force represented by 1,000 units, or 10 per cent of the force already employed by our Allies. How long will it take the combined force of 11,000 units to obtain a decision? This may be shown by the table which follows. It will be noted that the losses inflicted on the Teutonic forces during the first and each later period are 10 per cent of the forces with which the Allies started that period; similarly, the losses sustained by the Allies are 10 per cent of the initial Teutonic force. The force remaining at the end of any period is, of course, the force with which the next period is started.

TABLE I

	Force at beginning of Period		Losses sustained during Period		Force remaining at end of Period	
Period	Teutons	Allies	Teutons	Allies	Teutons	Allies
I.....	10,000	11,000	1,100	1,000	8,900	10,000
II.....	8,900	10,000	1,000	890	7,900	9,110
III.....	7,900	9,110	911	790	6,989	8,320
IV.....	6,989	8,320	832	699	6,157	7,621
V.....	6,157	7,621	762	616	5,395	7,005
VI.....	5,395	7,005	701	539	4,694	6,466
VII.....	4,694	6,466	646	469	4,048	5,997
VIII.....	4,048	5,997	600	405	3,448	5,592
IX.....	3,448	5,592	559	345	2,889	5,247
X.....	2,889	5,247	525	289	2,364	4,958
Total Losses			7,636	6,042		
Per Cent of Force Lost			76.36	54.93		



Graphs showing economy of time and material effected by our maximum participation in the war

Table I shows that at the end of ten periods the Teutons are reduced to less than one-half our remaining force. But we assume that the attainment of this "half" mark, fully demonstrated, means the end of the war. A more detailed study of the figures will show that this condition is reached in 9.7 periods, when the resulting figures are

	Remaining Force	Total Losses	Per cent Losses
Teutons.....	2,522	7,478	74.78
Allies.....	5,045	5,955	54.14
Allied losses, as compared with Teutonic.....			79.7

Next, let us study a United States force of 5,000, or 50 per cent of the force already employed by our Allies.

TABLE II

	Force at beginning of Period		Losses sustained during Period		Force remaining at end of Period	
Period	Teutons	Allies	Teutons	Allies	Teutons	Allies
I.....	10,000	15,000	1,500	1,000	8,500	14,000
II.....	8,500	14,000	1,400	850	7,100	13,150
III.....	7,100	13,150	1,315	710	5,785	12,440
Total Losses			4,215	2,560		
Per Cent of Force Lost			42.15	17.07		

Table II shows that after three periods we are more than twice as strong as the enemy. A more detailed study of the figures will show that the "half" mark is reached in 2.55 periods, when the resulting figures are

	Remaining Force	Total Losses	Per cent Losses
Teutons.....	6,377	3,623	36.23
Allies.....	12,760	2,240	14.93
Ratio of Losses.....		61.8	

In a similar way, we might trace the analysis through a series of tables, each showing the result of a definite, assumed value of the United States force. This has been done for United States forces varying from 500 (five per cent of our Allies' force) to 8,000 (80 per cent of our Allies' force) and the final results shown in Table III and in the Diagram. Any one desiring to check the figures may easily do so by the methods explained above. There is no need of showing all the detail here.

TABLE III

Forces Employed			Losses Sustained by					
Teutons	Allies	Periods Required	Teutons	Per Cent	Allies	Per Cent	U. S. Alone	Ratio Allied Losses to Teuton Losses
10,000	10,500	13.04	8,272	82.72	7,038	67.03	335	85.1
10,000	11,000	9.70	7,478	74.78	5,955	54.14	541	79.7
10,000	12,000	6.48	6,291	62.91	4,578	38.15	763	71.2
10,000	13,000	4.68	5,313	53.13	3,622	27.86	838	68.2
10,000	14,000	3.46	4,439	44.39	2,870	20.50	820	64.7
10,000	15,000	2.55	3,633	36.23	2,240	14.93	747	61.8
10,000	16,000	1.84	2,860	28.60	1,706	10.66	640	59.7
10,000	17,000	1.26	2,116	21.16	1,216	7.15	501	57.5
10,000	18,000	0.77	1,386	13.86	770	4.28	344	55.5

In the diagram, the vertical heights represent numbers of time periods or quantities or percentages of losses, all based on the employment of United States forces as shown across the bottom. For instance, if the United States should use a force equal to 25 per cent of that now in use by our Allies, the following results may be found from the curves:

Number of Time Periods	5½
Total Allied Losses	4,030
Percentage Allied Losses	32
Total Teutonic Losses	5,770
Total United States Losses	800
Ratio, Allied to Teutonic Losses	70%

But the main value of the diagram is that it shows graphically how rapidly the Allied losses diminish with increasing United States forces at work, and how much more quickly the Teutons are thus whipped. This shows conclusively that Mr. Roosevelt is emphatically right every time he says, "Hit with all your might; never hit soft," etc.

Now with regard to the column in Table III headed "U. S. alone." It is assumed that the Unted States losses are in the same ratio as the Allied losses as a whole. If the Allied loss is 54.1 per cent, the United States loss is 54.1 per cent of our total force employed; similarly with 14.9 per cent and each other percentage shown. On this basis, the total United States losses are seen to increase with increasing forces engaged up to a certain point, after which they fall. The percentage losses, of course, fall sharply with each addition to the force we put into action. So, from a purely selfish point of view, it might be argued that a small force is the way to limit our own individual losses. But it is seen that a very large force will limit them in the same degree, and get the job over very much more quickly. Incidentally, it will save our Allies from the possible danger of utter exhaustion.

Increasing our force from 1,000 to 3,000 will increase our individual losses from 541 to 838 units; but it will decrease our total (Allied) losses from 5,955 to 3,622 and the losses of our Allies from 5,414 to 2,784. In other words, by accepting an increased loss of 297 units, the United States can save her Allies a loss of 2,630 units, or nearly nine times as much. There can be but one answer to such a suggestion.

And we have no desire to cripple the German nation so terribly as a long-drawn-out war would do it. We do not want them to lose 83 per cent of their entire force, if we can get exactly the same results—the full measure of our aims—while they lose only 14 per cent. We've all got to inhabit this same planet when the war is over; and any loss to any combatant is, in the last analysis, a loss to humanity. It is human life and the work of men's hands and of men's minds deliberately destroyed; and the whole world is the poorer for that destruction.

So, by all means, let us put our shoulders to the wheel, and push as we have never pushed before. Thus, and thus only, can we win the war with least sacrifice and insure a lasting peace.

Coöperation

When Will the Allies Learn the Formula Used So Successfully by the Teuton?

By An Italian Military Expert

WHEN Italy went into the war in May, 1915, she did not do it merely to free from a foreign yoke the Italian cities of Trento and Trieste, as many people believe. Undoubtedly, that idea was prevalent in the minds of the majority of the Italian soldiers; and it was encouraged to a certain extent by the authorities, since it is a well known fact that the uneducated fighter does immensely better work when he is facing death for a definite, specific, tangible aim. But the Italian people of the better class realized that the first months of the world war had given ample proof that the questions at issue went above and beyond territorial readjustments or even national policies; that the world was in the crucible, and that the efforts required of all right-thinking people in order to crush Hohenzollernism must be not only gigantic, but inter-related.

Even the moment chosen for Italy's entrance into the war gave a proof of that spirit of international discipline and of willing helpfulness which has ever been at work in the most responsible centers of the Peninsula. It is now an open secret that while Italian participation on the side of the Allies was to have taken place in July, preparations were rushed during the first half of May in order to bring it about within that month—thus saving the Russian colossus from a tremendous defeat at the hands of the Teuton coalition. It was, therefore, with the stamp of coöperation indelibly imprinted upon her work that Italy, perfectly aware of the horrors of war which she had been able to witness as an outside spectator for ten months, became on May 25th, 1915, a member of the Allied family.

But the word "coöperation" cannot be mentioned today without a feeling of tragic irony, as we hear of the Italian soldiers allowed to fight single-handed on the banks of the Piave against the Austro-German avalanche, made more powerful by the elements recently released from duty on the Russian front, where during the kaleidoscopic change of Muscovite political and military events only a few hundred thousand superannuated or crippled Teutons have been left to fraternize with the liberty-drunk Russian soldiers.

American newspaper correspondents have sent us extremely illuminating accounts of the work of the Italians along that river which D'Annunzio, the new Tirteus of Italy, calls "the only sweet water" of his native land. Censorship has clearly shown its iron hand in those dispatches; but to the man accustomed to read between the lines in any dispatches from the front, those vivid descriptions of the epic Italian resistance provide ample food for thought. "Fighting is going on desperately, the Italians using hand grenades, bayonets, and pocket knives." The intelligent reader knows what this means: that for almost one month of fearful enemy attacks, the Italians have not yet been provided by their allies with any better weapons with which to defend themselves. "Austrians were shooting from the windows of the farm houses along the Piave." The intelligent reader will again be brought to realize that the existence of any farm houses on the Austrian side of the Piave after days and days of desperate fighting at close range proves that the Italians had no large caliber guns with which to destroy those houses.

Nor can Percival Gibbon, the correspondent who is responsible for those two statements, be accused of embellishing the truth with any artistic touches due merely to his own imagination. I can see him today, standing on the top of Monte Santo, surrounded by the bodies of the Italian soldiers who fell during the fearful attack of the Bainsizza, calm, silent, as he sketched the nearby San Gabriele whence at every second a new Austrian shell proceeded in our direction. Surely he loves the Italian soldiers, and it must have been cruel for him to follow them in their recent tragic retreat from that Isonzo front which they had conquered at such fearful cost in lives; but he is such a believer in inter-Ally solidarity that he would not have missed a chance to praise the work of any English, French, or American troops who might be coöperating with the Italians on the line which they hold with grim determination, in the hope of saving Venice from conquest and destruction.

The truth is that the Associated Press man did not describe any non-Italian troops because there were no such troops to be described. Italian troops have been defending single-handed the line of the Piave—inexplicably, inexcusably single-handed. One month has passed since the great drive began, and yet the Italians, who for two-and-a-half years had been able to curb and outwit the army of a country almost twice as great on a terrain as difficult as any on which the world war is being fought, are still allowed to withstand without any appreciable help the combined efforts of Germany and Austria. At the same time four armies are assembled in France—the French, the small but valorous Belgian, the British with all of its colonial additions, and now the American; and some of these have just started an offensive which may, to be sure, bring the usual result of relieving pressure, but which is surely consuming more men and *material* than would be required to save the ominous Italian situation by direct action.

Far be it from me to accuse any of our great allies of selfishness, of wilful neglect, of inefficiency. Such accusations would be in the first place untrue, and in the second place contrary to the good of the Allied cause. Yet history is now writing dark pages for us all, and oceans of heroic blood demand that the cause be found and loudly proclaimed. Our present helplessness is merely due to our contempt for coöperation—a contempt, the destructive results of which we have long felt, but not yet remedied.

The case of Italy provides a sensational example now, but it has provided one as appropriate for almost a year. It is well known that the Austro-Italian front has long been the most vulnerable spot in the armor of the Central Powers. The military experts of practically all countries, the United States included, have known that the Italian contention was right. Yet each country felt that if final victory were won on its own particular front, the fact would add greatly to its own prestige. Such fronts may be either revised versions of old frontiers, or lines chosen in an emergency years ago and now considered as pertaining *pro tempora* to the countries which chose them. Who would dare criticise in an unfriendly way a country like Great Britain, which was transformed into a fighting power of the first magnitude almost over night? Yet we cannot deny that while that country knew how to jump at the throat of a robber who entered the home of a neighbor through the main door, she failed to see that the robber might just as well be expelled

(Concluded on page 445)

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

The Nullification of Torpedo Shock

To the Editor of the SCIENTIFIC AMERICAN:

I have been extremely interested in all experiments directed toward this end. The efforts of Alfred A. Shore, recorded in your number of October 27th, deserve, I believe, special attention. It is very probable that the experiments which he performed can be made the basis of a device that will actually render useless the explosive power of the torpedo.

However, although worthy of high comment, I think that Mr. Shore's idea is embryonic. Following up the principle that in order to relieve the shock on the ship, which is the line of least resistance because of the immense amount of sea-water backing up the force of the explosion, it will be necessary to establish another line of least resistance, I have completed an experiment which, I hope, will prove to be another stage in the development of the above embryo.

(1) Filled a cylinder three feet high and two feet in diameter with salt-water. The weight of salt per volume corresponded to that of ordinary sea-water. A piece of iron was mounted in the middle of the cylinder, in which was placed a blank cartridge. The top of the cylinder was tightly fitted with a cover which came in contact with the surface of the water. The cover was arranged with a small opening which was connected with an "S" shaped tube. The half of this tube closest to the opening contained air, while the rest of the tube contained mercury. The cartridge set in iron was exploded by means of an insertion molded in the cylinder. The force of the explosion expelled the mercury from the tube.

(2) The apparatus was arranged the same as before, except that the cylinder was fitted with a positive and a negative electrode and connected with an electric current. Immediately after the current was turned on, the cartridge was exploded. But the mercury was not expelled from the tube. The force of the explosion was just as great the second time as the first, but in the first case, the force was exerted upward, while in the second, it was exerted downward. As a result, the support upon which the cylinder was resting collapsed after the second explosion.

The force was exerted upward as shown by the mercury in the first case, because the opening in the cover of the cylinder offered the line of least resistance, just as the ship offers the line of least resistance to the force of the torpedo when that force is backed by ordinary sea-water. The force was exerted downward in the second case as shown by the collapse of the support, because the electric current produced a condition in the water below the explosion which offered a line of least resistance, thus changing the direction of the force.

The electrolysis of water decomposes it into hydrogen and oxygen. The liberation of these gases is exceedingly rapid when there is proper adjustment between the electrodes and the current. The gases create a tremendous foaming in the water, which tends to create a vacuum. This temporary vacuum affords the new line of least resistance.

Also, the electrolysis dissociates the salt dissolved in the water into its ions. This process creates a solution that has a lesser density than before. Therefore it offers less resistance to the force of the explosion.

I believe that the actual electrolysis of the immediate water surrounding a ship is not beyond the approach of modern science. Perhaps such an arrangement would only partially nullify the force of the torpedo, but the combination of several "partial nullifiers" proposes to solve the torpedo problem.

CLARENCE M. BRITTON.

Fremont, Neb.

Static Electricity and the Fire Hazard

To the Editor of the SCIENTIFIC AMERICAN:

I have noticed that a large part of the fires throughout the United States occur on cool days when the winds are from the west, the air being very dry. This kind of weather is very favorable to produce static electricity and may be the cause of some of the explosions in the munition works. I have seen sparks of static electricity produced by the soot from boiler tubes with steam through a rubber hose against the tubes; this will not always do it as it depends on the condition of the atmosphere.

Several years ago an assistant came to me and reported that our dynamo must be badly grounded because he got severely shocked when he touched the steam pipe; the place he pointed out was overhead in the fireroom near the basement ceiling. We got a short ladder up and I found it was a small leak of invisible dry steam blowing downward from the stuffing box spindle of the stop valve. It was a very small leak and almost noiseless, but we found that the moment we stepped on the rungs of the ladder we were charged like a Leyden jar. We had considerable fun with this by calling over any one that was not posted and asking him to hold a wrench, when we would both get a bad shock. This would not work every day.

In New Mexico some years ago I had a rubber belt that ran quite fast and it ran horizontal about three and one-half feet from the floor; if we walked within 15 inches of it a thin long spark would jump out, feeling or though one had a pin stuck into him. The air there is very dry. I have noticed that sometimes even while it is raining conditions are favorable for producing static electricity. I remember once coming out of the rain into our engine room, I stood near a Wimhurst Electric Machine. I happened to have on a new pair of rubber shoes and I walked over to another part of the room and touched something when a spark came from me; I found that I was charged with static electricity. I got some one to turn on the gas jet and I could light it with my finger. I have never been into a munition factory or powder works, but have often thought that there should be no insulated parts of the machinery where a quantity of electricity might get stored and then finally a destructive spark jump out and cause disaster.

E. D. H.

Brooklyn, N. Y.

Steam Engines Wanted for Small Boats

To the Editor of the SCIENTIFIC AMERICAN:

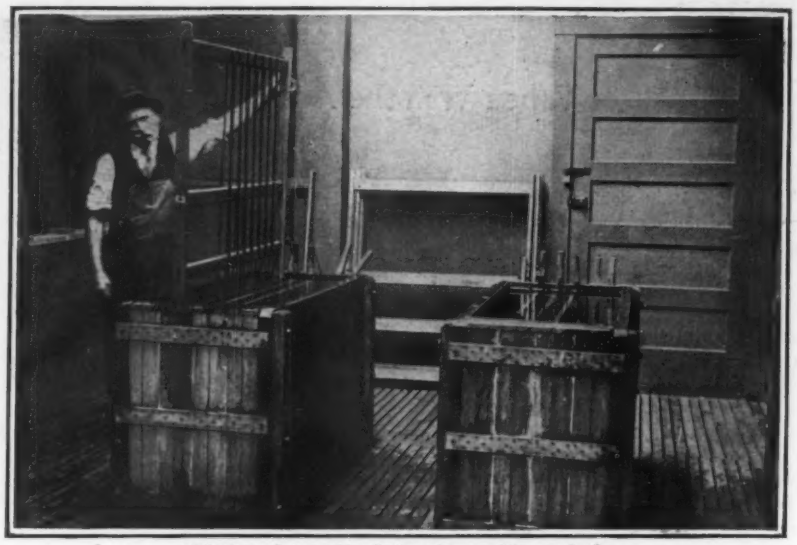
There is a crying need for a steam motor for small motor boats—say 2 to 15 horse-power. Who will invent and build such a motor and thereby make a fortune? Some such principle could be employed as has been so successful in steam motor cars.

Steam is a positive power. Gasoline is erratic and unreliable especially in motor boat engines. For years I have been trying to find a gasoline engine I could run and depend upon, but am convinced that no such engine is built or ever will be. I am ready to place an order as soon as a steam motor is on the market and there are thousands of others like me.

M. T. RICHARDSON.

Ashland, N. H.

Tanks and racks used in developing film



Motion-picture film being thoroughly washed

From the Camera to the Screen

How Motion-Picture Films are Developed, Printed, Titled, Tinted, Dried and Polished

By Austin C. Lescarboura

A GRAIN of dust, a slight variation in a chemical solution, an impure water supply, an otherwise insignificant fluctuation in the voltage of the current supply of the printing lamps, a trifling rise or fall in the temperature, an inconsiderable shrinkage of the film —all these factors can mark the difference between a clean, clear and steady picture on the motion-picture screen, and a spotty, indistinct, and jumpy film unfit for use. Which means that once the film leaves the camera, the work of the actors, director and cameraman is entirely in the hands of the laboratory staff; and upon the experience, skill, and care of this staff depend the screen results.

Dust, The Motion Picture's Arch Enemy

At regular intervals the raw stock is received at the motion-picture laboratory in such quantities as always to ensure a fresh supply. Usually the film is unperforated when received, for the reason that, to insure accurate perforations, it is best to perforate it just before it is placed in the camera or in the printing machine. Film perforated long in advance might shrink, and where accuracy is considered in terms of hundredths of an inch, this would not do. So the first step in the laboratory is to prepare the raw stock, either negative or positive, in the perforating room.

To perforate the plain film great care must be exercised, for upon the accuracy of this work depends the steadiness of the picture on the screen. The machines perforate one set of holes at a time, after which the film is moved forward to the required distance to perforate another set, the operation being intermittent and not continuous. The perforators are operated with scrupulous care, and special attention is given to maintain rigid and uniform conditions of both humidity and temperature. Above all, the perforating room must be devoid of dust and

The developing of motion-picture negatives is much the same as that of amateur films. The film is received in either the camera magazine or in a tin case, and upon being removed from the container it is wound on a wooden rack, emulsion side out. The rack is then placed in a narrow, vertical tank containing the developer and the developing process allowed to proceed. But while the amateur photographer has merely to place the contents of a packet into so much water, and then deposit his film in this solution for so many minutes, the motion-picture worker handling hundreds and thousands of feet of film, has to make sure that his solution is in constant motion. To this end it is the usual practice to keep the developing solutions in constant circulation, while to ensure perfect results the temperature is carefully maintained at a fixed standard.

The film racks are occasionally lifted from the developing tanks and brought in front of dim ruby lamps to ascertain the extent of the development, and it is such movement of the racks which prevents air bubbles and subsequent markings from appearing on the finished film.

Great care is required in preparing the developing solutions. Hundreds of gallons of developer is prepared daily in the larger laboratories, and in each case a skilled chemist makes certain by analytical tests that it is of the proper composition. Formerly, these solutions were prepared by a sort of rule-o'-thumb; the workers placed a half-barrel of this constituent, three scoopfuls of that, and a pinch of a third into five barrels of water, and if their work did not turn out quite right, they unblushingly blamed it on some unknown condition. But today such procedure is no longer tolerated, for the industry has reached the highest standards. The developing solutions are carefully watched and tested at intervals, and when the first signs of exhaustion appear they are discarded.

Films, after they are thoroughly washed, are placed in tanks containing the fixing solution so as to remove the unaffected or free silver, making them transparent. Again they are placed in the washing tanks, this time for even a longer period to make sure that every trace of the fixing solution is eliminated.

Now the celluloid strips, still on the original racks, are sent to the drying room. Here they are taken off the racks and wound on huge wood or metal drums which are revolved at a fair speed. This drying operation is carried out in a room whose temperature is such as to insure absolute dryness; and the air, too, is carefully adjusted so as to aid this condition. It goes without saying that the drying room is barred to dust of all kinds.

Time was when the film producer had to depend on the weather in drying his films; and on rainy days it was next to impossible for him to make any headway. He decided, at last, to sever all connections with the weather man; and today the work goes on whether it is wet or dry outdoors: the drying room is in reality a little world by itself where the dryness and the temperature are

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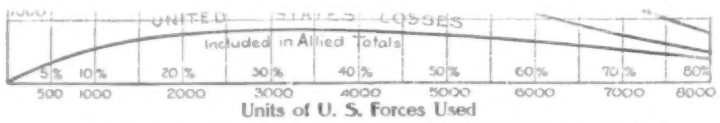
leadership. When Warren fell at Bunker Hill, it was said that his loss was equal to that of 1,000 men. Perhaps it was. But in the intricate ramifications of modern war forces, it would be futile to try to evaluate all the elements which, combined, make for success; scattered, for failure. At the same time, it must be recognized that such a value exists. It may change from day to day; but at each instant there is some quantity which quantity simultaneously represents the other. This fact is the basis of our calculation.


UNITED STATES LOSSES
Included in Allied Totals
5% 10% 20% 30% 40% 50% 60% 70% 80%
500 1000 2000 3000 4000 5000 6000 7000 8000
Units of U. S. Forces Used

Graphs showing economy of time and material effected by our maximum participation in the war

Now let us assume, which is perfectly rational, that in a certain unit of time one force (A) may damage another force (B) an amount equal to 10 per cent of A's strength; similarly, and during that same interval of time. B damages A an amount equal to 10 per cent of B's strength. Thus, a force of 1,000 would do its enemy twice as much damage, in one hour or one week, as would a force of 500. And we do not need to know what the period of time is. It varies. During the progress of a terrific bombardment and assault it is short; in the relatively inactive winter months it is long—perhaps five hundred times as long as during the most active operations. And it varies with the percentage which we assume as the loss ratio. It would approximately be twice as long, on the average, for a loss of 10 per cent as for a loss of 5 per cent; twice as long for 20 per cent as for 10 per cent.

Next, let us assume that, when the enemy's force is reduced to one-half of ours, the logic of the situation will be borne home to him; that he will see the futility of further resistance, and the war will end. We might have made this ratio one-third or two-fifths, or any other value which individual judgment might set. The general result would be the same; and, though the time required to achieve that result would vary with each new ratio chosen, our *comparative* answer would still hold.

Table I shows that at the end of ten periods the Teutons are reduced to less than one-half our remaining force. But we assume that the attainment of this "half" mark, fully demonstrated, means the end of the war. A more detailed study of the figures will show that this condition is reached in 9.7 periods, when the resulting figures are

	Remaining Force	Total Losses	Per cent Losses
Teutons	2,522	7,478	74.78
Allies	5,045	5,955	54.14
Allied losses, as compared with Teutonic			79.7

Next, let us study a United States force of 5,000, or 50 per cent of the force already employed by our Allies.

TABLE II

	Force at beginning of Period		Losses sustained during Period		Force remaining at end of Period	
Period	Teutons	Allies	Teutons	Allies	Teutons	Allies
I	10,000	15,000	1,500	1,000	8,500	14,000
II	8,500	14,000	1,400	850	7,100	13,150
III	7,100	13,150	1,315	710	5,785	12,440
Total Losses			4,215	2,560		
Per Cent of Force Lost			42.15	17.07		

Table II shows that after three periods we are more than twice as strong as the enemy. A more detailed study of the figures will show that the "half" mark is reached in 2.55 periods, when the resulting figures are

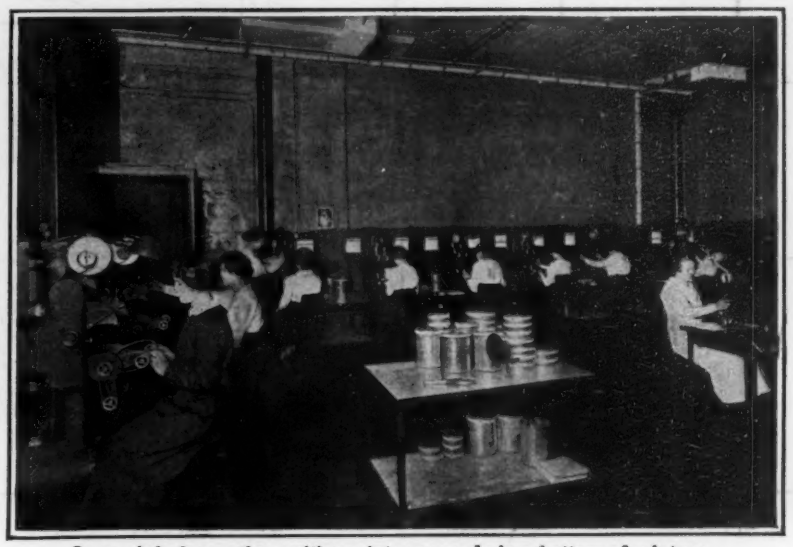
per cent and each other percentage shown. On this basis, the total United States losses are seen to increase with increasing forces engaged up to a certain point, after which they fall. The percentage losses, of course, fall sharply with each addition to the force we put into action. So, from a purely selfish point of view, it might be argued that a small force is the way to limit our own individual losses. But it is seen that a very large force will limit very much more quickly. Incidentally, it will save our Allies from the possible danger of utter exhaustion.

Increasing our force from 1,000 to 3,000 will increase our individual losses from 541 to 838 units; but it will decrease our total (Allied) losses from 5,955 to 3,622 and the losses of our Allies from 5,414 to 2,784. In other words, by accepting an increased loss of 297 units, the United States can save her Allies a loss of 2,630 units, or nearly nine times as much. There can be but one answer to such a suggestion.

And we have no desire to cripple the German nation so terribly as a long-drawn-out war would do it. We do not want them to lose 83 per cent of their entire force, if we can get exactly the same results—the full measure of our aims—while they lose only 14 per cent. We've all got to inhabit this same planet when the war is over; and any loss to any combatant is, in the last analysis, a loss to humanity. It is human life and the work of men's hands and of men's minds deliberately destroyed; and the whole world is the poorer for that destruction.

So, by all means, let us put our shoulders to the wheel, and push as we have never pushed before. Thus, and thus only, can we win the war with least sacrifice and insure a lasting peace.

Huge drying drums which can handle thousands of feet at a time



In semi-darkness the positive prints are made in a battery of printers

girls rub their soft hands over thousands of feet of film in the course of the day's work. Of course, one must have absolutely dry hands to qualify as film polisher.

Working Year After Year in Darkness

With the negative in its finished form, we are ready to make positive prints. As in the case of amateur photography, the negative film shows the image in reversed order, with the whites in black and the blacks in white, and a print is necessary to obtain the proper order of black and white. And just as in the case of prints on paper, it is possible to make any number of prints from the motion-picture negative.

Positive stock is not as sensitive to light as the negative stock, hence can be handled in a room provided with numerous ruby lamps, as compared to the almost total darkness of the perforating and the developing rooms. Still, to the stranger the room is uncomfortably dark; and it is with marked surprise that he notes the ease with which the operatives carry on their work. It appears that these workers, toiling day in and day out in semi-darkness, develop their eyesight to a point where they can see almost as well in the dim red light as they can at twilight outdoors. At any rate, they appear to have no trouble in this direction.

The negative film is run through a printing machine face to face with fresh positive stock—the emulsion faces in contact. Each time a negative image comes into position in front of an aperture, a shutter allows a flash of light to pass through it and onto the positive stock in back, after which the two films are pulled down the space of one picture, bringing the next image into position. Thus the printing operation proceeds one picture at a time until the entire negative is run off.

If negatives were all of one density the printing of positives would be a simple matter. But negatives vary to a great extent, and almost every one requires a different printing time. So the first step in making a print is to determine the density of its negative. Some laboratories simply run off a foot or two on the printer with different adjustments of the light, and then develop the strip so as to note the tones and select the proper one. Other laboratories have a set of negative strips of varying intensities arranged in front of a lamp, and simply

fore appreciate how careful the motion-picture workers must be to maintain a constant and known intensity of light in their printers, and a flawless mechanism. In the more up-to-date laboratories each lamp is tested daily with a photometer to ensure standard and uniform intensity.

Positive film is developed, fixed, and washed much after the manner of the negative film, after which it is dried and polished in the ways already described. But there are occasions where certain strips are to be tinted or toned, in which case special treatment is required before the final operations.

A vast difference exists between tinting and toning. Tinting has to do with making the celluloid stock of the positive film take on any desired color, so that the entire picture appears of that one color and black. Toning, on the other hand, has to do with converting the blacks into any desired color, but leaves the celluloid stock untouched or colorless. By combining the tinting and toning operations many beautiful effects can be obtained, such as *tinting* the film a light buff and *toning* it a dark blue. Tinting is mostly carried on with dyes, while toning requires mineral salts and chemicals which in some colors are now very scarce. The treatment in either case consists in dipping the film, as it comes from the washing tanks, into the vats of coloring matter, and removing it only after the desired shade is attained, after which it is given a final washing.

How Motion-Picture Titles Are Made

Again with titles, diversity of methods available is not lacking. Some laboratories prefer to print the copy for titles on plain pieces of paper, in bright red ink, thus obtaining a negative. Others print the titles in white on a black background, thus obtaining a direct positive effect. In either case the services of a printer-compositor are required, and also a skilled pressman who can pull clean proofs on a small job press. A method which has passed out of favor of late is to lay out the titles with movable ornamental borders and letters on a background of black plush, permitting rapid changes.

The titles are photographed with a motion-picture camera in the same manner as would be the case with a scene, and the resulting negative or positive is avail-

able for any number of prints or in any quantity.

By this time small rolls of positive film containing up to 200 feet of film make their way to the assembling room, where they are ready to be examined and cut and assembled into finished productions. Although it is not generally known to the public, we never see but the abridged film of any given production; that is to say, the average five-reeler is actually made up from ten thousand or more feet of film, trimmed down to size. For it is a physical impossibility for the producer to make a production of five thousand feet with only five thousand feet of film. Many scenes have to be retaken and many are found unnecessary to the story when examined on the screen.

Editing a film is perhaps the most interesting phase of laboratory work. The editor, usually the director himself in dramatic productions, directs the cutting and assembling of the various strips of film into the complete production; and just as the editor of a magazine reads the printer's proofs and makes his corrections, so does the film editor view the assembled film on the screen and make corrections and changes. Finally, when the film is approved of, it is used as a standard for the assembly of duplicate films by skilled girl assemblers.

Packed in round cans the film reels find their way to the exchanges throughout the world, and from the exchanges they make their way to the projectors in thousands of picture theaters, there to entertain the millions of devotees of the motion-picture screen.

The Current Supplement

A TOPIC that is attracting considerable attention is the possibility of building ships of concrete. An article in the current issue of the SCIENTIFIC AMERICAN SUPPLEMENT, No. 2188, for December 8th, on *Ferro-Concrete Shipbuilding* gives much valuable information on the subject, together with novel methods adopted in construction and launching. It is accompanied by several photographs of a craft recently built abroad, together with a number of drawings showing details of construction. The important paper on *The War's Effect on Merchant Shipbuilding* is concluded in this issue. *Military Aircraft and Their Armament* describes some of the problems of warfare in the air, and now they

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directed toward this end. The efforts of Alfred A. Shore, recorded in your number of October 27th, deserve, I believe, special attention. It is very probable that the experiments which he performed can be made the basis of a device that will actually render useless the explosive power of the torpedo.

However, although worthy of high comment, I think that Mr. Shore's idea is embryonic. Following up the principle that in order to relieve the shock on the ship, which is the line of least resistance because of the immense amount of sea-water backing up the force of the explosion, it will be necessary to establish another line of least resistance, I have completed an experiment which, I hope, will prove to be another stage in the development of the above embryo.

(1) Filled a cylinder three feet high and two feet in diameter with salt-water. The weight of salt per volume corresponded to that of ordinary sea-water. A piece of iron was mounted in the middle of the cylinder, in which was placed a blank cartridge. The top of the cylinder was tightly fitted with a cover which came in contact with the surface of the water. The cover was arranged with a small opening which was connected with an "S" shaped tube. The half of this tube closest to the opening contained air, while the rest of the tube contained mercury. The cartridge set in iron was exploded by means of an insertion molded in the cylinder. The force of the explosion expelled the mercury from the tube.

(2) The apparatus was arranged the same as before, except that the cylinder was fitted with a positive and a negative electrode and connected with an electric current. Immediately after the current was turned on, the cartridge was exploded. But the mercury was not expelled from the tube. The force of the explosion was just as great the second time as the first, but in the first case, the force was exerted upward, while in the second, it was exerted downward. As a result, the support

thus changing the direction of the force.

The electrolysis of water decomposes it into hydrogen and oxygen. The liberation of these gases is exceedingly rapid when there is proper adjustment between the electrodes and the current. The gases create a tremendous foaming in the water, which tends to create a vacuum. This temporary vacuum affords the new line of least resistance.

Also, the electrolysis dissociates the salt dissolved in the water into its ions. This process creates a solution [illegible] before. Therefore it offers less resistance to the force of the explosion.

I believe that the actual electrolysis of the immediate water surrounding a ship is not beyond the approach of modern science. Perhaps such an arrangement would only partially nullify the force of the torpedo, but the combination of several "partial nullifiers" proposes to solve the torpedo problem.

CLARENCE M. BRITTON.

Fremont, Neb.

Static Electricity and the Fire Hazard

To the Editor of the SCIENTIFIC AMERICAN:

I have noticed that a large part of the fires throughout the United States occur on cool days when the winds are from the west, the air being very dry. This kind of weather is very favorable to produce static electricity and may be the cause of some of the explosions in the munition works. I have seen sparks of static electricity produced by the soot from boiler tubes with steam through a rubber hose against the tubes; this will not always do it as it depends on the condition of the atmosphere.

Several years ago an assistant came to me and reported that our dynamo must be badly grounded because he got severely shocked when he touched the steam pipe; the place he pointed out was overhead in the fire-

[illegible] years ago I had a rubber belt that ran quite fast and it ran horizontal about three and one-half feet from the floor; if we walked within 15 inches of it a thin long spark would jump out, feeling or though one had a pin stuck into him. The air there is very dry. I have noticed that sometimes even while it is raining conditions are favorable for producing static electricity. I remember once coming out of the rain into our engine room, I stood near a Wimhurst Electric Machine. I happened to have on a new pair of rubber shoes and I walked over to another part of the room and touched something when a spark came from me; I found that I was charged with static electricity. I got some one to turn on the gas jet and I could light it with my finger. I have never been into a munition factory or powder works, but have often thought that there should be no insulated parts of the machinery where a quantity of electricity might get stored and then finally a destructive spark jump out and cause disaster.

E. D. H.

Brooklyn, N. Y.

Steam Engines Wanted for Small Boats

To the Editor of the SCIENTIFIC AMERICAN:

There is a crying need for a steam motor for small motor boats—say 2 to 15 horse-power. Who will invent and build such a motor and thereby make a fortune? Some such principle could be employed as has been so successful in steam motor cars.

Steam is a positive power. Gasoline is erratic and unreliable especially in motor boat engines. For years I have been trying to find a gasoline engine I could run and depend upon, but am convinced that no such engine is built or ever will be. I am ready to place an order as soon as a steam motor is on the market and there are thousands of others like me.

M. T. RICHARDSON.

Ashland, N. H.

Tanks and racks used in developing film

Motion-picture film being thoroughly washed

From the Camera to the Screen

How Motion-Picture Films are Developed, Printed, Titled, Tinted, Dried and Polished

By Austin C. Lescarboura

A GRAIN of dust, a slight variation in a chemical solution, an impure water supply, an otherwise insignificant fluctuation in the voltage of the current supply of the printing lamps, a trifling rise or fall in the temperature, an inconsiderable shrinkage of the film —all these factors can mark the difference between a clean, clear and steady picture on the motion-picture screen, and a spotty, indistinct, and jumpy film unfit for use. Which means that once the film leaves the camera, the work of the actors, director and cameraman is entirely in the hands of the laboratory staff; and upon the experience, skill, and care of this staff depend the screen results.

Dust, The Motion Picture's Arch Enemy

At regular intervals the raw stock is received at the motion-picture laboratory in such quantities as always to ensure a fresh supply. Usually the film is unperforated when received, for the reason that, to insure accurate perforations, it is best to perforate it just before it is placed in the camera or in the printing machine. Film perforated long in advance might shrink, and where accuracy is considered in terms of hundredths of an inch, this would not do. So the first step in the laboratory is to prepare the raw stock, either negative or positive, in the perforating room.

To perforate the plain film great care must be exercised, for upon the accuracy of this work depends the steadiness of the picture on the screen. The machines perforate one set of holes at a time, after which the film is moved forward to the required distance to perforate another set, the operation being intermittent and not continuous. The perforators are operated with scrupulous care, and special attention is given to maintain rigid and uniform conditions of both humidity and temperature. Above all, the perforating room must be devoid of dust and dirt, for tiny specks on either negative or positive stock loom up big when magnified thousands of times on the screen; indeed, all film operations must be carried out in the form of a constant combat with the dust menace. Still another phase of perforating is to condition the air properly, so that static electricity will not develop and spoil the film by permanently marking it with lightning-like streaks. Lastly, when the film is perforated it is given a farewell cleaning so that all dust accumulations and cuttings are removed. As can well be imagined this work is carried out in almost total darkness, such light as is permissible being supplied by ruby lamps.

The developing of motion-picture negatives is much the same as that of amateur films. The film is received in either the camera magazine or in a tin case, and upon being removed from the container it is wound on a wooden rack, emulsion side out. The rack is then placed in a narrow, vertical tank containing the developer and the developing process allowed to proceed. But while the amateur photographer has merely to place the contents of a packet into so much water, and then deposit his film in this solution for so many minutes, the motion-picture worker handling hundreds and thousands of feet of film, has to make sure that his solution is in constant motion. To this end it is the usual practice to keep the developing solutions in constant circulation, while to ensure perfect results the temperature is carefully maintained at a fixed standard.

The film racks are occasionally lifted from the developing tanks and brought in front of dim ruby lamps to ascertain the extent of the development, and it is such movement of the racks which prevents air bubbles and subsequent markings from appearing on the finished film.

Great care is required in preparing the developing solutions. Hundreds of gallons of developer is prepared daily in the larger laboratories, and in each case a skilled chemist makes certain by analytical tests that it is of the proper composition. Formerly, these solutions were prepared by a sort of rule-o'-thumb; the workers placed a half-barrel of this constituent, three scoopfuls of that, and a pinch of a third into five barrels of water, and if their work did not turn out quite right, they unblushingly blamed it on some unknown condition. But today such procedure is no longer tolerated, for the industry has reached the highest standards. The developing solutions are carefully watched and tested at intervals, and when the first signs of exhaustion appear they are replaced by fresh lots.

The Question of Pure Water and Plenty of It

When the film has been developed to the required degree, it must be washed to remove all traces of developer. For this purpose the film, still on the wooden rack, is placed in a large tub through which passes a constant stream of water. As in the case of the chemicals every drop of water must be filtered and known to be chemically pure before it is allowed to come in contact with the film. This means that a pure supply must be available in the first place, and that batteries of filters must be used to remove all particles of foreign matter.

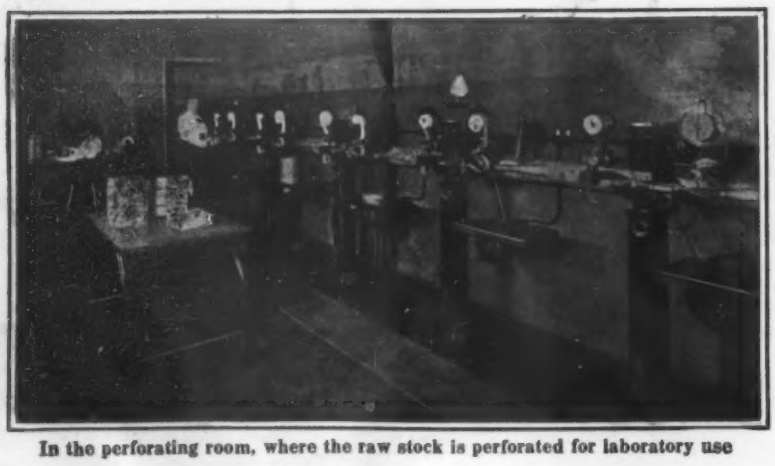
Several years ago a film laboratory experienced considerable trouble in its work: films were never quite up to the required standard, although the same staff had turned out an excellent product when located in another part of the same city. Chemists were called in, and they immediately set to work analyzing the water supply. They found that the water, taken from a nearby river, contained considerable quantities of an undesirable substance, and advised the producer to that effect. Whereupon the producer had a special well sunk to a depth of over a thousand feet on his own property, in order to tap a virgin supply of water, which in this case turned out to be just the kind required.

Films, after they are thoroughly washed, are placed in tanks containing the fixing solution so as to remove the unaffected or free silver, making them transparent. Again they are placed in the washing tanks, this time for even a longer period to make sure that every trace of the fixing solution is eliminated.

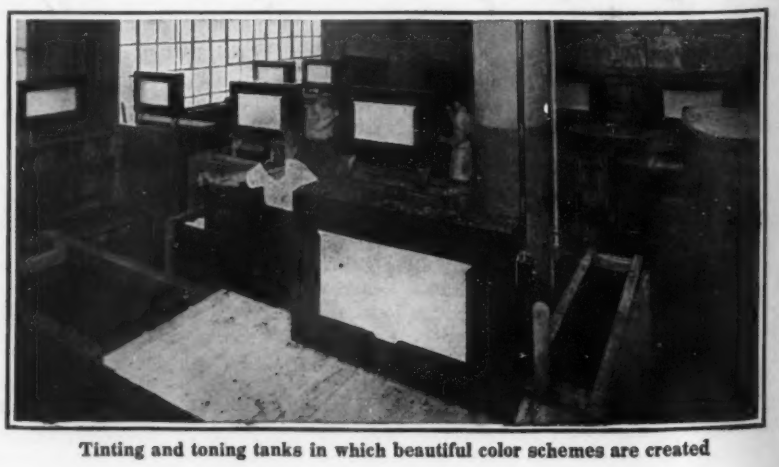
Now the celluloid strips, still on the original racks, are sent to the drying room. Here they are taken off the racks and wound on huge wood or metal drums which are revolved at a fair speed. This drying operation is carried out in a room whose temperature is such as to insure absolute dryness; and the air, too, is carefully adjusted so as to aid this condition. It goes without saying that the drying room is barred to dust of all kinds.

Time was when the film producer had to depend on the weather in drying his films; and on rainy days it was next to impossible for him to make any headway. He decided, at last, to sever all connections with the weather man; and today the work goes on whether it is wet or dry outdoors: the drying room is in reality a little world by itself where the dryness and the temperature are regulated by the mere twist of an electric controller. Thousands of feet of film can be dried at one time on a battery of drying drums, and this method prevents the film from developing troublesome bends or twists.

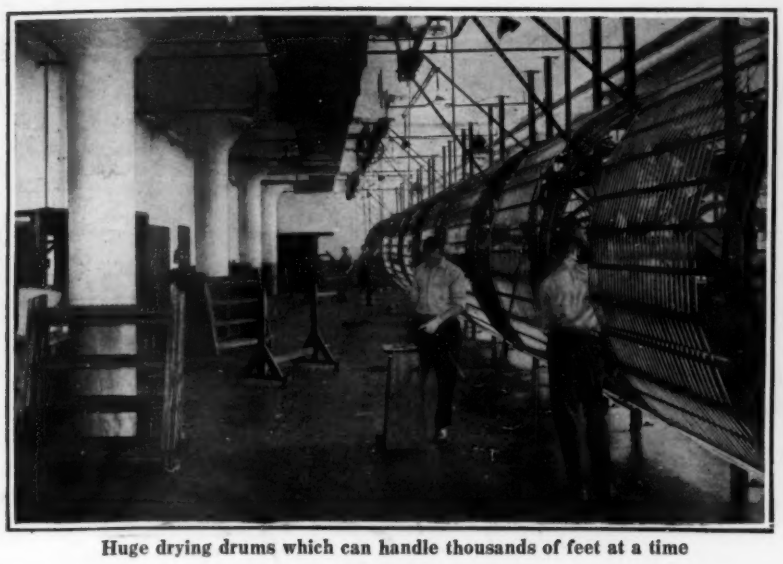
No matter how perfect the drying process may be, a negative always comes out of the drying room with numerous spots which are nothing more than the solid matter left after the water evaporates. To remove these spots the dried film is wound on a drum a few feet in diameter and covered with soft cheese-cloth, and polished by girl operatives. Strangely enough, the best polishing material is the palm of the hand, and these



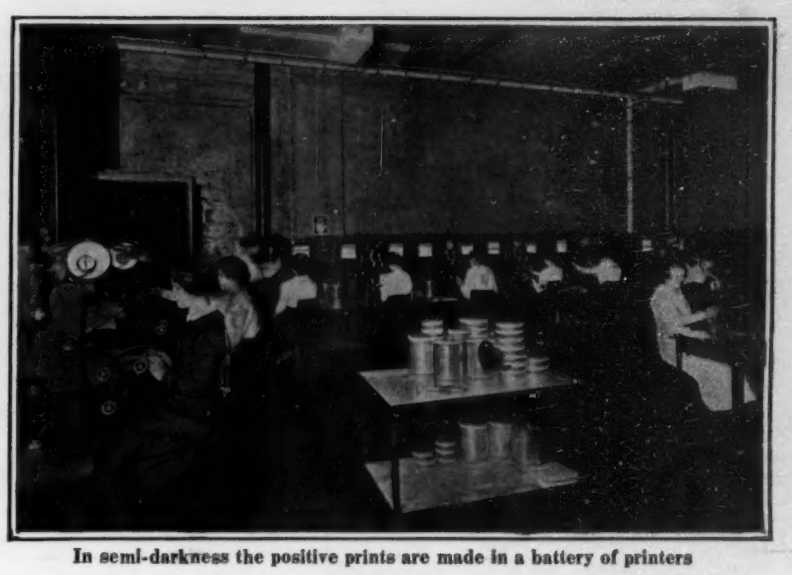
In the perforating room, where the raw stock is perforated for laboratory use



Tinting and toning tanks in which beautiful color schemes are created



Huge drying drums which can handle thousands of feet at a time



In semi-darkness the positive prints are made in a battery of printers

girls rub their soft hands over thousands of feet of film in the course of the day's work. Of course, one must have absolutely dry hands to qualify as film polisher.

Working Year After Year in Darkness

With the negative in its finished form, we are ready to make positive prints. As in the case of amateur photography, the negative film shows the image in reversed order, with the whites in black and the blacks in white, and a print is necessary to obtain the proper order of black and white. And just as in the case of prints on paper, it is possible to make any number of prints from the motion-picture negative.

Positive stock is not as sensitive to light as the negative stock, hence can be handled in a room provided with numerous ruby lamps, as compared to the almost total darkness of the perforating and the developing rooms. Still, to the stranger the room is uncomfortably dark; and it is with marked surprise that he notes the ease with which the operatives carry on their work. It appears that these workers, toiling day in and day out in semi-darkness, develop their eyesight to a point where they can see almost as well in the dim red light as they can at twilight outdoors. At any rate, they appear to have no trouble in this direction.

The negative film is run through a printing machine face to face with fresh positive stock—the emulsion faces in contact. Each time a negative image comes into position in front of an aperture, a shutter allows a flash of light to pass through it and onto the positive stock in back, after which the two films are pulled down the space of one picture, bringing the next image into position. Thus the printing operation proceeds one picture at a time until the entire negative is run off.

If negatives were all of one density the printing of positives would be a simple matter. But negatives vary to a great extent, and almost every one requires a different printing time. So the first step in making a print is to determine the density of its negative. Some laboratories simply run off a foot or two on the printer with different adjustments of the light, and then develop the strip so as to note the tones and select the proper one. Other laboratories have a set of negative strips of varying intensities arranged in front of a lamp, and simply compare the negative with the standard samples to obtain the printing factor. In either case the density of the negative is obtained and marked on the negative; in this manner the girl operatives know how to adjust the intensity of the light or the speed of the printer when the roll comes to them.

Anyone who has made prints on fast, gaslight papers realizes how important are the light intensity and the printing time in this kind of work. And he can therefore appreciate how careful the motion-picture workers must be to maintain a constant and known intensity of light in their printers, and a flawless mechanism. In the more up-to-date laboratories each lamp is tested daily with a photometer to ensure standard and uniform intensity.

Positive film is developed, fixed, and washed much after the manner of the negative film, after which it is dried and polished in the ways already described. But there are occasions where certain strips are to be tinted or toned, in which case special treatment is required before the final operations.

A vast difference exists between tinting and toning. Tinting has to do with making the celluloid stock of the positive film take on any desired color, so that the entire picture appears of that one color and black. Toning, on the other hand, has to do with converting the blacks into any desired color, but leaves the celluloid stock untouched or colorless. By combining the tinting and toning operations many beautiful effects can be obtained, such as *tinting* the film a light buff and *toning* it a dark blue. Tinting is mostly carried on with dyes, while toning requires mineral salts and chemicals which in some colors are now very scarce. The treatment in either case consists in dipping the film, as it comes from the washing tanks, into the vats of coloring matter, and removing it only after the desired shade is attained, after which it is given a final washing.

How Motion-Picture Titles Are Made

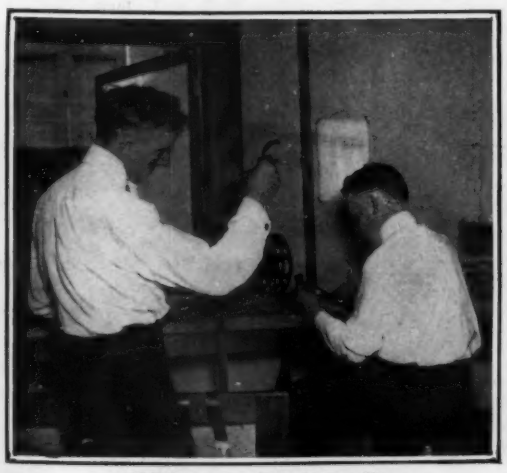
Again with titles, diversity of methods available is not lacking. Some laboratories prefer to print the copy for titles on plain pieces of paper, in bright red ink, thus obtaining a negative. Others print the titles in white on a black background, thus obtaining a direct positive effect. In either case the services of a printer-compositor are required, and also a skilled pressman who can pull clean proofs on a small job press. A method which has passed out of favor of late is to lay out the titles with movable ornamental borders and letters on a background of black plush, permitting rapid changes.

The titles are photographed with a motion-picture camera in the same manner as would be the case with a scene, and the resulting negative or positive is available for any number of prints or in any quantity.

By this time small rolls of positive film containing up to 200 feet of film make their way to the assembling room, where they are ready to be examined and cut and assembled into finished productions. Although it is not generally known to the public, we never see but the abridged film of any given production; that is to say, the average five-reeler is actually made up from ten thousand or more feet of film, trimmed down to size. For it is a physical impossibility for the producer to make a production of five thousand feet with only five thousand feet of film. Many scenes have to be retaken and many are found unnecessary to the story when examined on the screen.

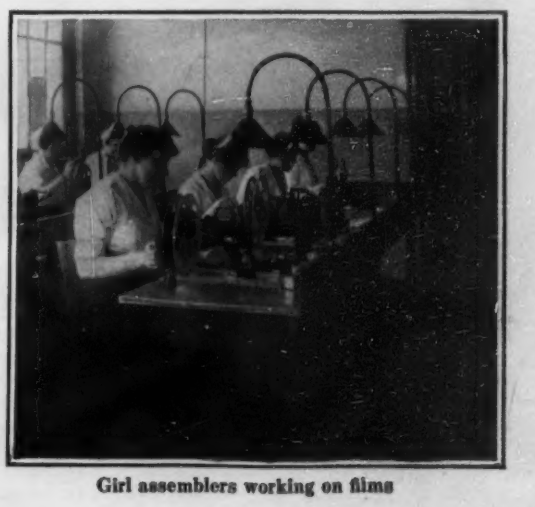
Editing a film is perhaps the most interesting phase of laboratory work. The editor, usually the director himself in dramatic productions, directs the cutting and assembling of the various strips of film into the complete production; and just as the editor of a magazine reads the printer's proofs and makes his corrections, so does the film editor view the assembled film on the screen and make corrections and changes. Finally, when the film is approved of, it is used as a standard for the assembly of duplicate films by skilled girl assemblers.

Packed in round cans the film reels find their way to the exchanges throughout the world, and from the exchanges they make their way to the projectors in thousands of picture theaters, there to entertain the millions of devotees of the motion-picture screen.



Editing a motion-picture film

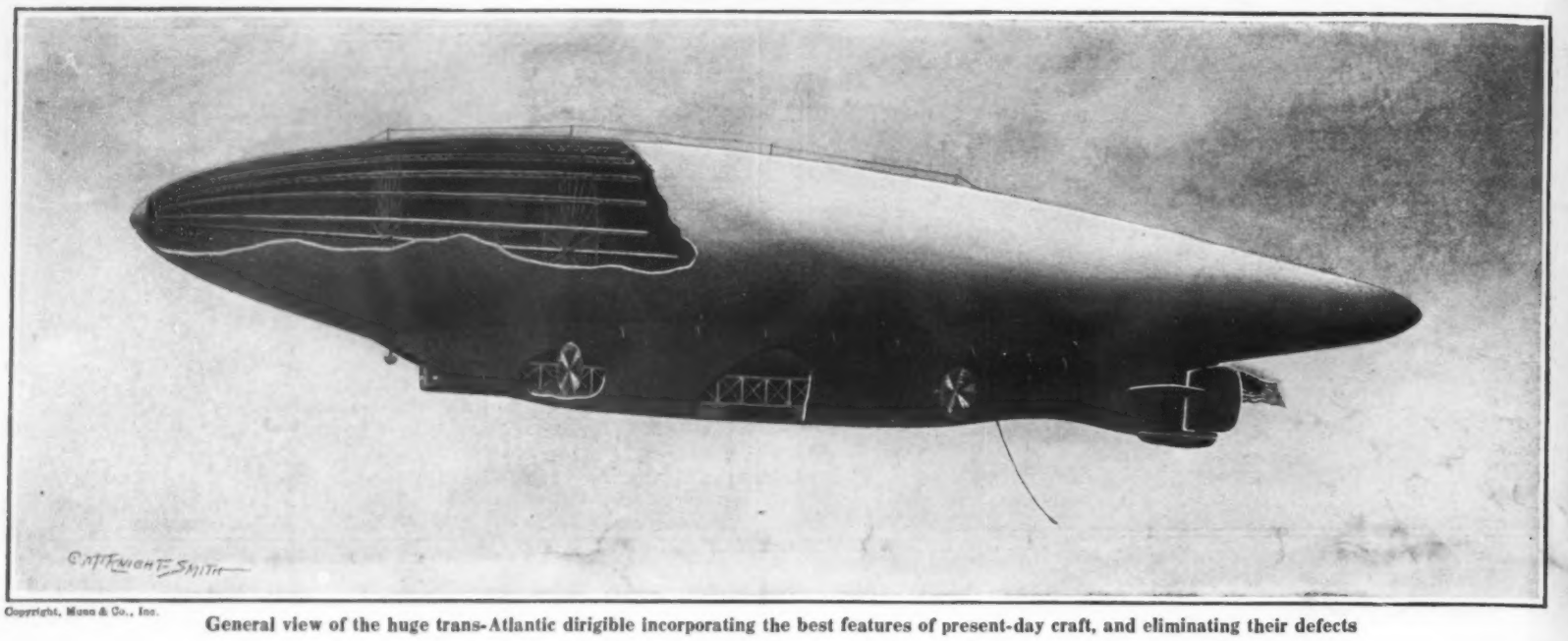
Finished films ready for shipment



Girl assemblers working on films

The Current Supplement

A TOPIC that is attracting considerable attention is the possibility of building ships of concrete. An article in the current issue of the SCIENTIFIC AMERICAN SUPPLEMENT, No. 2188, for December 8th, on *Ferro-Concrete Shipbuilding* gives much valuable information on the subject, together with novel methods adopted in construction and launching. It is accompanied by several photographs of a craft recently built abroad, together with a number of drawings showing details of construction. The important paper on *The War's Effect on Merchant Shipbuilding* is concluded in this issue. *Military Aircraft and Their Armament* describes some of the problems of warfare in the air, and how they have been met by improved methods of construction. *The Inertia of Energy* deals with fundamental problems on which important theories of physics are based. *Companions of the Sun* describes in a popular manner some of the more intimate features of the solar system and will be found of unusual interest by the general reader. An article of wide technical interest is on *Wave Detectors for Wireless*, which reviews the history of an important class of devices with illustrations and diagrams.



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General view of the huge trans-Atlantic dirigible incorporating the best features of present-day craft, and eliminating their defects

Trans-Atlantic Airships

Advanced Ideas for Dirigibles Based on What the Germans Have Done

By Alexandre Livventaal, Late Consulting Engineer to Count Ferdinand von Zeppelin

ZEPPELIN! The most universally known, printed, admired and cursed name! Zeppelin airships! The most universally misunderstood, exalted, overestimated, hated, feared and underestimated machine of the present war! Such is the opinion of the world at large regarding the German airship constructor and his huge dirigibles.

But let us investigate Count Zeppelin's work with an unbiased and open mind; let us apply to the records of his aerial achievements the acid test of scientific criticism and positive analysis.

The gas bubble in a spherical form gives the greatest lifting power for the smallest surface of skin. This type of balloon is well known either as the captive balloon for observation purposes or as the free balloon drifting with the winds. When the gas bubble is to be propelled by mechanical power through the air at a fair speed, it has to be shaped along lines of least resistance, for obvious reasons. Skin surface increases and the finer the lines of the body the greater the surface of the gas bag for the same volume of gas. The greater the surface the greater the loss of gas through "exosmosis" and the greater the diffusion of air into the gas through "endosmosis."

The regularity of the form of the gas bag being kept by an internal pressure of gas—an average of 50 kilos per square meter (about 110 pounds to the square yard)—it follows that a moment arrives when the outer pressure of air on the head of the dirigible due to the forcing of the body through the atmosphere, is so great that the bag bursts. To obviate such defect and to be able to obtain speeds ranging up to 70 miles an hour, Zeppelin divided his gas bag into 17 transversal sections and enclosed them separately within a rigid elongated frame. Each cell became, in this manner, an independent unit of the "free" type, having its independent filling neck and safety valve. The gas was at liberty to expand or to contract in accordance with the variations of atmospheric pressure and temperature. The circular parts of the cells rested against the upper parts of the frame and the flat sides rested on each side of the spider web, constructed of aluminum and steel wires which divided the airship into independent compartments.

The whole of the rigid frame was enclosed in a special cover made of strong fabric, allowing a free space of about five inches between itself and the gas cells. Underneath the airship, three cars, connected by an inside passage, were fixed on the frame. The distance from the floor of the car to the lower part of the frame was about 2½ meters. The fore and aft cars were engine cars, while the middle one was the navigating room, with wireless equipment, bombing apparatus, switchboard, and the cargo of bombs. The propellers were fixed on the frame at a certain height, and driven from the car by means of gearing and long side-shafts. On the stern of the airship were affixed the steering and elevating planes, as well as the fin areas.

So much for the main characteristics. The load, carried by the frame, is concentrated on three points. Besides the strain due to this concentration of weights, the frame is designed and constructed to resist the extra bending moments resulting from the deflation of any two of the gas cells.

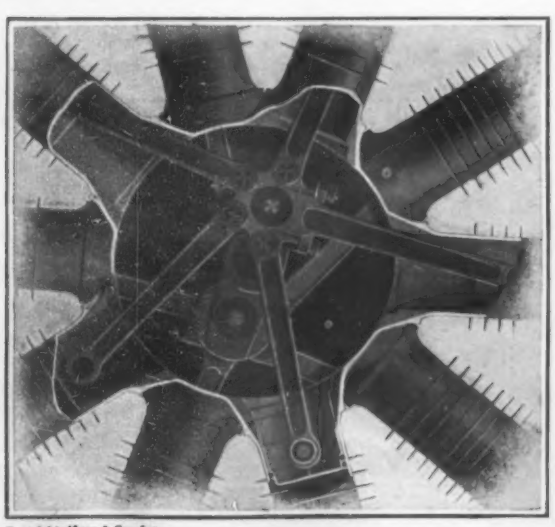
The ultimate consequence is that the frame and the outside cover absorb such considerable lifting power that the gas cells, owing to their enormous surfaces, have had to be made of the lightest possible material and yet retain a coefficient of strength and gas tightness sufficient to warrant long-distance flights. Such was, without experimental data to work upon, the plausible and speculative solution of the problem as it evolved out of Count Zeppelin's brains.

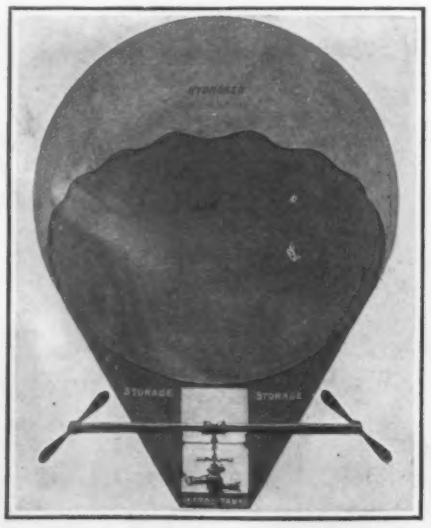
The Zeppelin dirigible has been submitted to the test of practical operation for a period of over seventeen years, during which the record flights over the Alps to Salonica, over the North Sea to Scotland, the convoying of certain ships from Tromsoe, the sea scouting at the Jutland fight, the convoying of submarines and raiders through the mine fields and the British fleet, and the bombing of Paris, London, Bucharest and Riga, are well-known accomplishments. Zeppelin's invention has, so far, not proved to be a failure. Being alone in the field of long distance aerial navigation, Zeppelin dirigibles hold unchallenged records.

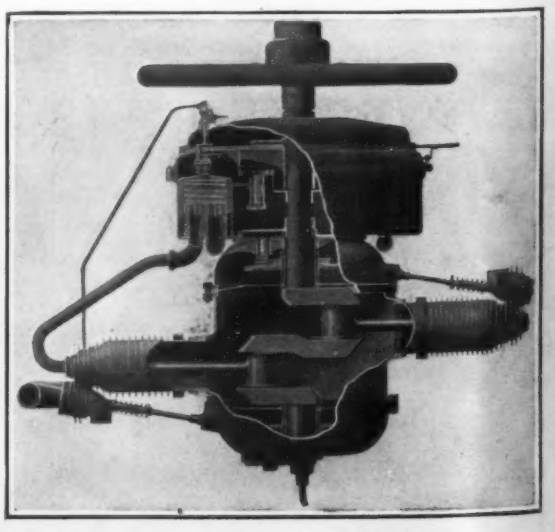
But Zeppelins also hold unchallenged records of bad luck and disasters, such as sinking at sea, forced landings in exhausted condition in various countries, taking fire in their sheds, taking fire outside of their sheds and during aerial journeys, being driven down through climatic conditions or by shell fire or motor accidents, and so on. Yet with the exception of a very few instances where destruction was the "Act of God," as it is known to the seafaring men, all the other accidents could have been spared had Zeppelin and his German staff fully derived and learned the lessons contained in every one of the mishaps that befell them. For instance, in the very first experiments made in July, 1900, the lifting capacity of the airship was hardly sufficient to ensure a sound test of the machine. The frame could not stand the strain and buckled into a sausage shape; and the fore and aft propellers, being no longer in line, the airship performed all sorts of wild gymnastics and steered in any but a straight and steady course. The vibration due to the motors, propellers and the whipping of the side shafts, was transmitted to the frame, and being intensified by the elasticity of the latter it soon chafed holes through the gas cells at every point of contact. The result was an excessive and unsuspected loss of gas and a hurried alighting on the surface of Lake Constance some five miles from the point of departure. The sagging and flapping of the outside cover on and between the ribs of the rigid frame proved at once to be a great hindrance to speed.

Since the first experiments, the frame has been greatly improved in its construction by the use of embossed members and the employment of "Duralumin," but its weight has nevertheless proportionately increased as well as the weight of the outside cover. Proportionately, too, the weight of the gas cells had to be further increased, and it is only by the use of silk and goldbeater's skin

(*Concluded on page 446*)







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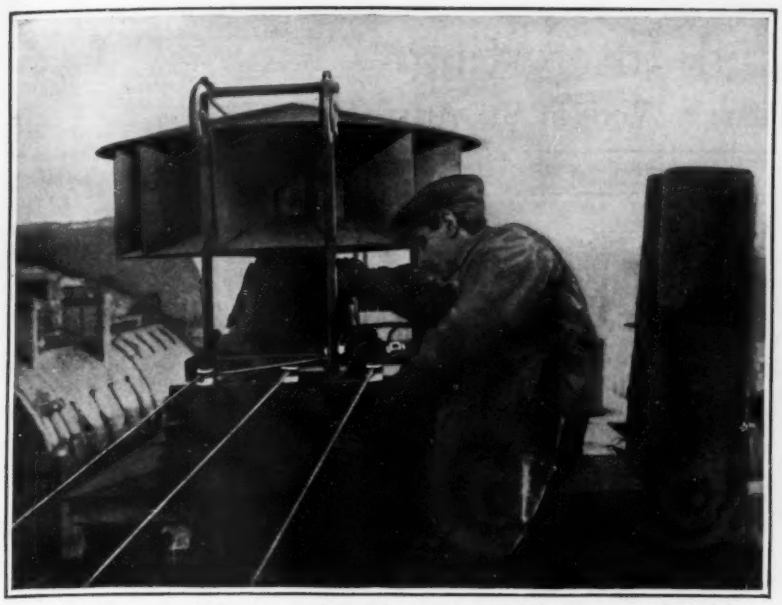
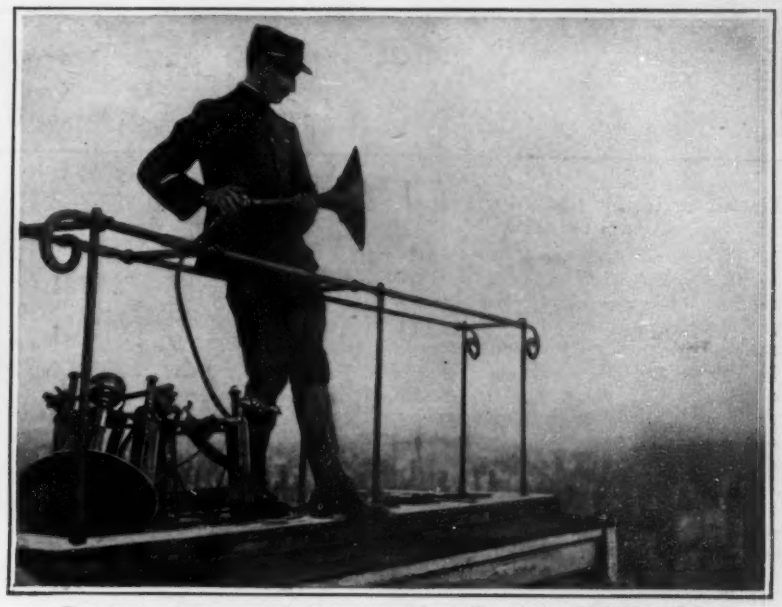
Arrangement of the piston rods and crank shafts — Power plant, fuel storage, and transmission system — Horizontal engine which burns gasoline and hydrogen

Some of the more prominent features of the power plant for the proposed trans-Atlantic dirigible



Electrically operated and provided with a number of radially-arranged sound chambers, this siren can be heard for miles



Two tanks of compressed air operate this shrill whistle which is used to warn Parisians of an impending air raid

The Howling and Shrieking Anti-Aircraft Batteries of Paris

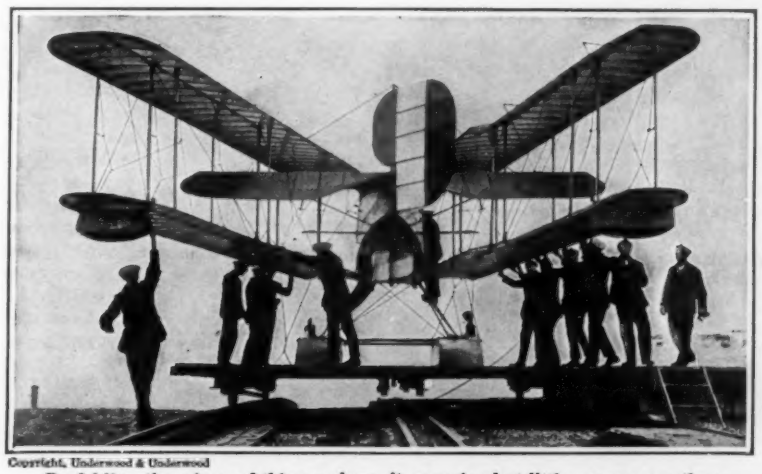
SURPRISE is a large factor in air raids. When the German airmen first appeared over Paris in the early days of the war, they collected a significant toll of human life because the Parisians were not sufficiently warned in the first place, and secondly, because they did not fear the bombs of the raider. The same applies to London. But the Parisians and Londoners have by now learned the dangers of air raids, and steps have been taken to warn them some time in advance of an impending air raid so that they can take to their subterranean shelters long before the first hostile bomb comes hurtling through the air.

Among the means employed to warn Parisians of impending air raids are whistles and sirens, located on roof tops in various parts of the city. Two types of equipment are shown in the accompanying illustrations. The first of these appears to be a form of whistle equipped with a large horn and operated by means of compressed-air flasks, while the second is a powerful electric siren equipped with a circular sound distributor. The whistle type, two of which are shown in the second illustration, is evidently intended for portable use, since it is of light weight and the flasks are mounted on a framework which presumably is strapped to the operator's back. The siren, on the other hand, is a permanent installation. The base contains the sound-producing mechanism, and above this there are several radially-arranged sound chambers.

An Airplane Which Folds Up Like a Jack-Knife

IN storing or sheltering the usual airplane there is a tremendous amount of space wasted. This is due to the fact that the airplane is shaped like a T, with the wings representing the cross stroke, and the fuselage the stem. Efficiently handled, the airplane should take up but little more room than the stem or fuselage space. At least, so has the storage and sheltering problem struck the British authorities; and they have developed airplanes which are provided with folding wings.

Some time ago we illustrated in these columns one of the first British seaplanes provided with folding wings. We now present a similar type of folding-wing seaplane which is being used at a naval flying school along the English coast, because the method of folding the wings is so strikingly shown. The planes, which are hinged to the forward part of the fuselage, can be swung back until they are alongside the fuselage. The elevating planes, it will be noted, fit in between the planes and the struts. All in all, the folded seaplane can be accommodated well within a space 10 feet by 30 feet, instead of the usual space of 40 or more feet by 30 feet.



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By folding the wings of this seaplane, it occupies but little more room than the width of its rudder members

The system of handling the machine is also of interest. The seaplane is brought to the water's edge on a railway truck pushed by the men, which is obviously a far better method than that of sliding the seaplane over boards or transporting it on small trucks which fit under the pontoons.

What of China's Air Service?

AS one of the powers which constitute the Allied group engaged in the present war, the aviation status of China is of some interest at the present moment. There is little to write about, for news regarding that far-away country is not plentiful these days.

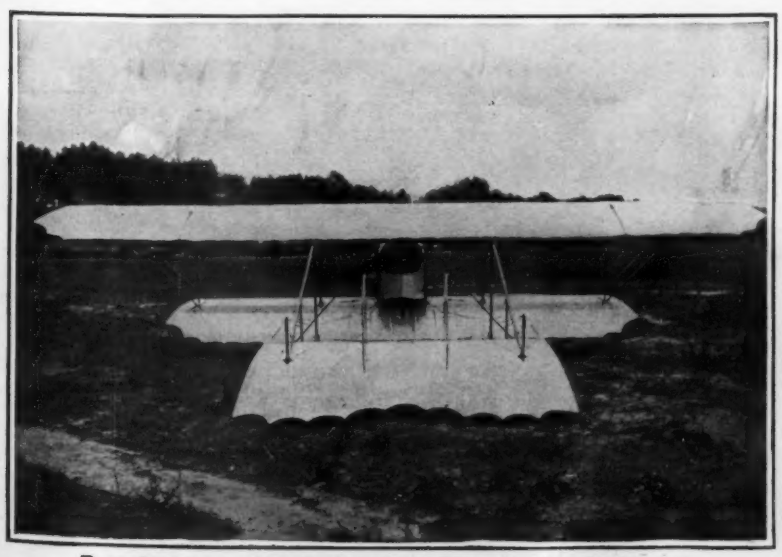
China, it appears, inaugurated her air service in 1913 by placing orders in France for six 80-horse-power and six 50-horse-power Caudron biplanes. At the same time it was decided to built up a large air fleet by adding new units from time to time; and since then slow but steady progress has been made toward this end. In 1913 a home-made machine was constructed at Nanuan, but on the whole the Chinese have preferred to purchase their machines abroad.

The military aviation school is at Pekin. For training purposes Caudron machines of the type shown in the accompanying illustrations, are used. This well-known French type of the ante-bellum period is of the tractor design, and in this particular instance is equipped with a six-cylinder, radial, air-cooled Anzanni engine developing forty-five to fifty horse-power. The mark or seal of the Chinese air service is a plain five-point star.

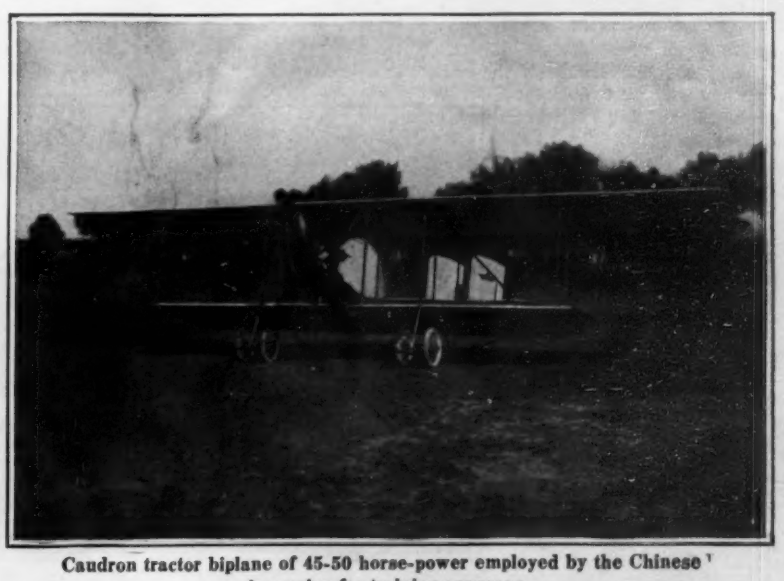
During the "White Wolf" operations in 1914, four of the Caudrons were employed by the army. They proved most effective in locating the enemy, thus furnishing a new incentive to the Chinese air service. No casualties to the machines occurred. The rapid development of aeroplane manufacture in Europe made it inevitable that China should turn to France or England for machines.

Cotton Substitutes in Germany

A REPORT from Germany dated last September states that although comparatively little raw cotton has been available lately in that country, spinners have been kept busy with recently introduced cotton substitutes. Nettle fiber is the most important of these, and is now produced on a large scale, exclusively for military use.



Rear view of one of the Caudron biplanes employed at the Chinese aviation school near Pekin



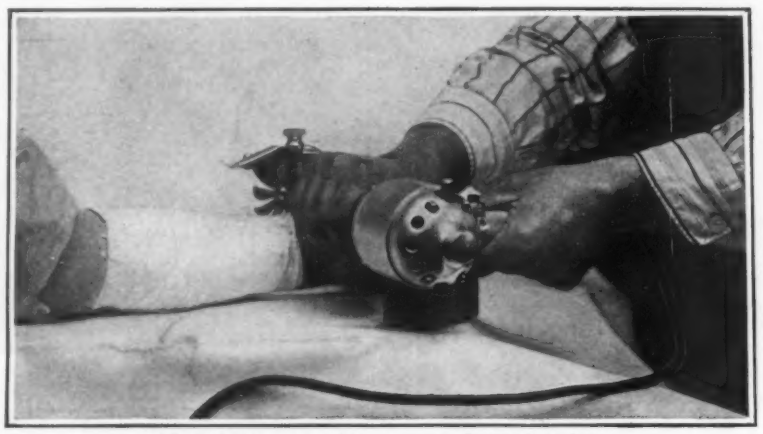
Caudron tractor biplane of 45-50 horse-power employed by the Chinese air service for training purposes

Inventions New and Interesting

A Department Devoted to Pioneer Work in the Arts

Electric Cutter for Removing Plaster of Paris Dressing

THE removal of plaster of Paris dressings by surgeons has been in a great measure a source of considerable pain to patients. The plaster after a few days offers great resistance to being removed. This procedure has been until now accomplished by means of scissors, knives, and saws, in the hands of the operating surgeon, with the result that the patient was the sufferer on account of the jerks and slow method of removal. We have today the electric surgical cutter, which operates absolutely painlessly, performing the operation in one swift clean cut of the dressing, be it on the limbs or the body.



The electric cutter that removes plaster dressings

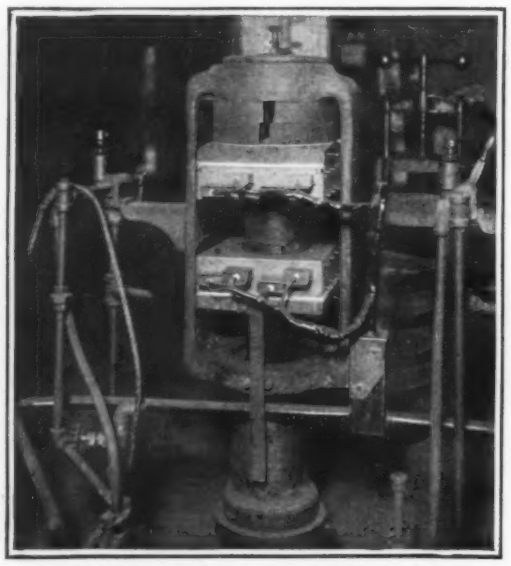
The instrument is motor driven. A rotary cutting wheel is attached to one end of the motor shaft. The knife, whose edges are concave, is so arranged that it will clear the cut automatically. A guard protects the operator and patient from accidental injury. Particles of the separating bandage can not fly, nor can dust annoy patient or operator, as a dust guard which slides to any distance is also provided for. A firm grasp is assured by having the handle of the instrument set at a right angle from the motor. Near one end is conveniently located a push button. When operating the instrument the part of the body to be worked upon is held firmly by the surgeon's assistant. The cutter is inserted beneath the dressing by simply pressing its dull point at the end of the guard of the knife a little downward. With this action it enters between the skin of the patient and the plaster Paris. As soon as the connection is made to a lamp socket, and the button pressed, the cutter swiftly and cleanly separates the bandage by one sharp incision.

Electrically Heated Molding Presses

IN industrial service electric heating has many advantages which represent actual saving of money, and which frequently effect sufficient increase in efficiency to offset any increase in cost over the more familiar steam installations. A step toward the more general application of electric heating in industrial processes has recently been made in the adoption of electric means for heating presses used in the manufacture of molded composition material. These presses were formerly heated by steam, but a trial press with electrical attachment proved so satisfactory that the entire set of 23 presses in this company's molded insulation factory is now being modified for equipment with electric heaters.

Our illustration shows the construction of the machines and the relation of the heaters to the presses. The heat is furnished by means of two plates one foot square and 3½ inches thick, with a magnesia covering on their exposed surfaces to reduce the loss by radiation. The upper plate is stationary and has a thermometer inserted in a little hole, to indicate the temperature obtaining. The lower plate moves vertically to secure the pressure effect. The heating units, embedded in grooves in the surface of the plates, are four in number and consist each of a flat ribbon resister assembled in a mica sheath and enclosed in a heavy steel casing. This construction reduces to a minimum the possibility of injury and also provides rapid transfer of heat from the resistance element, thus insuring long life under severe service conditions.

The controlling handle of the heaters is so arranged that by turning it to different positions varying voltages can be employed. The dial upon which it plays has 15 contacts and accordingly furnishes 15 voltages varying from a minimum of 150 volts to a maximum of 220. This arrangement provides for an in-put of high value for quick heating, when the press is cold before commencing the day's work; for one of low value when the press is out of operation but it is desired to keep it hot for later use; and several intermediate inputs as well, for keeping the press hot while in steady use on work possessing different heat requirements. The position of the controller for maintaining the press at the proper temperature with any given mold is of course regulated by experience.



The electric flat-iron on a factory scale

A New Wood, The Lightest Known

A NEW wood, apparently little known and called balsa wood, is exceedingly light and promises to have an extended field of usefulness in connection with cold storage structures when heat insulation is important. It is a tropical wood growing principally in the states of South and Central America.

The wood is remarkable, first, as to its lightness; second, as to its microscopical structure; third, for its absence of woody fiber; fourth, for its elasticity; and fifth, for its heat-insulating qualities. So far as the investigation has disclosed, it is the lightest commercially useful wood known. It has also considerable structural strength, which makes it suitable for many uses. In general appearance balsa wood resembles basswood. Until recently, Missouri cork wood, weighing 18.1 pounds per cubic foot, was believed to be the lightest, but recent investigations indicate that balsa wood is much lighter, having a net weight of 7.3 pounds per cubic foot. The ordinary commercial balsa wood is seldom perfectly dry, and, because of the moisture content, its weight has been found to be between eight and thirteen pounds per cubic foot.

The extreme lightness of this wood suggests its application as a buoyancy material in life-preservers and life-boats. When, however, it was attempted to apply the wood practically, it was found to be of little value, because it absorbed water in great quantities and also because it soon rotted and also warped and checked when worked. After testing nearly every method that had been suggested, Colonel Marr's method of treating woods which had been recently patented was finally successful. In this method the wood is treated in a bath, of which the principal ingredient is paraffin, by a process which coats the interior cells without clogging up the porous system. The paraffin remains as a coating or varnish over the interior cell walls, preventing the absorption of moisture and the ill-effects as to change of volume and decay which would otherwise take place; it also prevents the bad effects of dry rot which follow the application of any surface treatment for preserving wood of the same type. The Marr process tends to drive out all water and make the wood water-proof; it also improves its quality of being readily worked with tools, without material increase in weight. The treated balsa wood has been used extensively in the manufacture of life-preservers, fenders for lifeboats and for structures requiring insulation from heat, as in the refrigerating compartments of vessels and ice-boxes.

American Made "Salvarsan"

ONE of the most frequently advanced arguments illustrating the need for the recent act providing for the temporary confiscation of enemy patents was the shortage in this country of Salvarsan or "606," Dr. Ehrlich's specific for certain malignant blood poisons. Before the war this patented drug sold at four dollars per dose or about $3,500 per pound; since then it has brought as much as nine times this figure. Licenses to make it under the name "arsphenamine" have been granted three domestic chemists, and a price of $1 to $1.50 per dose to Army, Navy and physicians agreed on by the licensees.

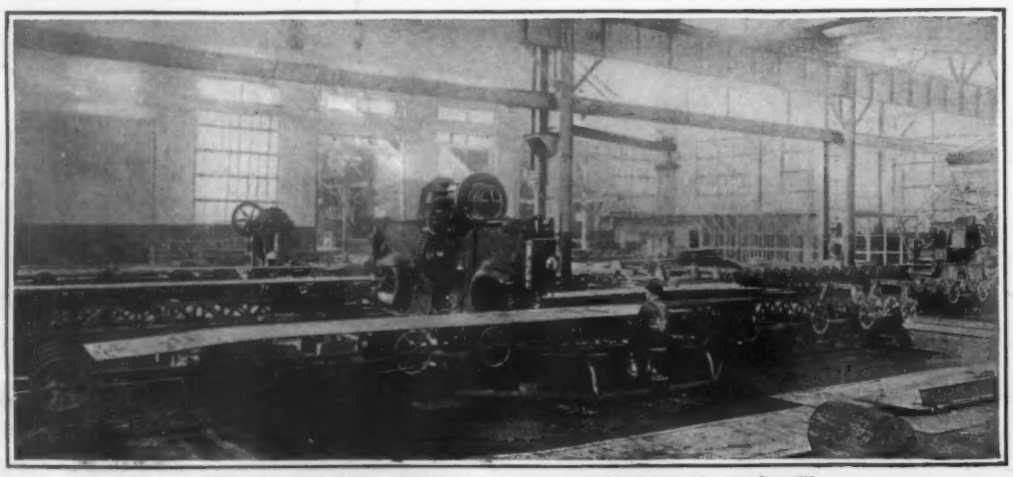
Punching Holes in Steel Plates at a Rapid Rate

PUNCHING over 4,000 holes in a 9-hour working day in heavy plates is a modern accomplishment to be proud of. It could not be done even only a year or two ago. Plates for building ships require many holes made in them for rivetting them together into a finished vessel. The great expansion of steel shipbuilding industries has made the rapid handling of plates at punching machines a real necessity. The Lysholm plate-punch roller tables, shown by the illustration, have made this possible, and are in use in many of the new plate shops.

In using this plate-punch roller table the plate is laid on the table and the operator, from his seat, moves the table backward and forward with the aid of an operating lever at his right hand. At his left hand is another lever, which can be operated to move the plate sideways, thereby placing it in the desired position for punching. Operation of the punch can be effected by the use of a foot lever conveniently located.

By this method plates from ¼ inch to 1⅜-inch thick and up to 30 x 8 feet may be handled. The tables are built with roller bearings to make operation easy. It is claimed that plates can be handled in one-half the time required by the old method, and the services of only one man at a machine are required.

The maker of this machine has records which were kept at various shipyards, showing that the number of holes punched per hour by this method has averaged from 420 to 670 on material varying in thickness from $\frac{5}{16}$ inch to 1⅛ inch, and from 5 to 8 feet wide by 24 to 30 feet long, the holes punched being $\frac{13}{16}$-inch in diameter up to 1$\frac{1}{16}$ inch in diameter.



The plate-punching machine that moves while the work stands still

An Opportunity for a Navy Career

TWO thousand intelligent young men in good physical condition are wanted at once for service in the Naval Reserve of the Second District, to take the places of reservists who have been advanced or transferred to other parts of the service. Originally there were 5,000 men enrolled in the Second Naval District Reserve service, but owing to the high standard of the personnel, the district has been drawn heavily upon to supply men for various branches of the naval service.

Many men interested in wireless telegraphy have been sent to the Navy Radio School at Harvard for instruction, while others have been retained at the school which is being conducted under the supervision of the District Communication Superintendent at Newport. A number have been sent to the Merchant Marine, which is known officially as the Naval Auxiliary Reserve. These men are at present in training, and before long they will be graduated as Warrant Boatswains, prepared for active sea duty on our transports. Still others have been sent to Annapolis for training to qualify them as Ensigns, and already one class of 24 men from this district has been graduated and the men detailed either to the fleet or to the much talked of 110-footers, the new Government submarine chasers. Others have been sent to the training school of the Second Naval District, from which they will be graduated prepared to receive their commissions as Ensigns in the Reserve. A great number of men from this district have also been transferred to the Naval Reserve Flying Corps. If these men make good at the ground school, and successfully pass their pilot's examination, they are assured a commission as Flight Ensigns in the Flying Corps.

From this it will be seen that the Naval Reserve presents a most attractive opportunity for the man who is willing to make his war enlistment and his war experience the starting point of a Service career. Many men whose circumstances are such that they have not felt able to offer themselves through any of the channels which involve service for the period of the war, followed by a sudden return to civil life under unfavorable conditions, will be able to take advantage of this opportunity, and are urged to do so.

All men desiring enrollment should, if possible, present themselves personally before the enrolling officer at the Naval War College, Newport, R. I., or before the recruiting officers at 42 Westminster Street, Providence, or Building 13, Brooklyn Navy Yard, or the Navy Recruiting Station, Park Place, Newark. There are also Navy recruiting Stations in Pittsburg, Minneapolis, and St. Louis. Applicants within the draft age must present a written statement from their local exemption board that they have not been drafted for the army and that they are free to enroll in the Naval Reserve. Applicants must be American citizens; if naturalized, having second papers. All men should be prepared to accept immediate active duty. The pay while on active duty is the same as that for enlisted men of the regular service of corresponding ratings, including all war increases and uniform gratuities.

Men having possible physical defects are cautioned that applicants are rejected by the examining surgeon for defective vision, color blindness, underweight, hernia or other serious physical defects. If there is any question as to physical qualifications it is advised that applicant undergo examination before presenting himself at Newport, and ascertaining by mail the probability of acceptance.

"Ten Million Pounds"

(Concluded from page 433)

satisfactory tests on materials which have inherently a low resistive power to great pressure—in which classification hollow tiles would naturally come, at least as compared with steel. But when it comes to steel and steel structures, especially members of bridges or buildings of any appreciable size, the Pittsburgh machine is usually the court of last resort. As an instance of its usefulness in work of this kind, mention may be made of the work done on the largest steel columns ever tested, which were half size models of chords for some great bridges erected in the middle west. These columns failed under load in various ways and places, some at the ends, some by lateral bending, others by a buckling local to a small part of the column. Nearly all, however failed only under pressures which very nearly approximated the yield points of the materials used, conclusively demonstrating the efficiency with which these members were put together.

The machine is an engineer's machine and the results are for the consideration of engineers. Too highly technical for details, the resulting tables of any investigation, whether it be the yield point of Mayari steel, or the elasticity of a hollow tile column, the strength advantage, if any, of Flemish over ordinary brick bond, or the added strength given a concrete column by special wire reinforcement, form notable additions to structural engineering science.

Incidentally, to see this mighty engine in full operation, so silently, so surely, and apparently without effort, break in pieces a great brick column or bend a bridge member as human hands might bend a green stick, is an experience worth going to Pittsburgh to have. And to remember that this resistless power is but a flexible leverage multiplication of a15 horsepower motor is to have made manifest the truth of that ancient boast of Archimedes that had he a fulcrum and a lever long enough, he could move the world.

Coöperation

(Concluded from page 439)

by another door through which it was infinitely less difficult to drive him.

Thinking people all over the world are deeply concerned over the forthcoming attitude of America in this respect. Is she going to follow the old shibboleth of the one important and three unimportant fronts, which has brought about our successive downfall on every one of our fronts. If America, so splendidly free from the military and political prejudices under which we Europeans are laboring, will at this moment of readjustment grasp the essential points of the situation and cut the Gordian knot, she can put us all to shame, spur us on to concerted action along the line of least resistance, and thus save the cause of civilization. She can see, indeed she does see, that it is in the interest of every one of us Allies, France and England included, to act jointly, swiftly, and powerfully on whatever part of the enemy lines confronting us seems most vulnerable. In the very name of that Lafayette whose personality stands now as a splendid sentimental link between France and America, I claim that the chief issue of this war is the triumph of that liberty for which he fought on two continents. Is it then in his name that France wishes to keep on her own soil all the human resources sent by the United States to fight in Europe for the downfall of Kaiserism?

I know that the sending of American soldiers to France presents less difficulties and less dangers than an expedition across seas thickly dotted with submarines; but landing in France is one thing, and fighting in France is another. I also know that the French people are aware of the future moral value of a fellowship of arms being formed now on their own soil; that they realize the interest in the French language and in French civilization which will result from the experiences of Americans in France; that they appreciate the desire of millions of Americans to visit, soon after peace is declared, the scene of American military exploits. Under the circumstances it must be a fearful temptation for France to try to keep for herself as many Sammies as she can get instead of saying to them: "Go, for you are more badly needed elsewhere." It would require heroism to say this; but we expect heroism from France, and we usually get it.

And there is another consideration not to be overlooked. France herself ought to realize that in this case it would be for her ultimate good to send the human

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material accumulated on her soil to the relief of an ally whose marvellous efforts have for two years and a half amazed the world, and who is now rapidly yielding ground. Is not the advance of the Hun upon Italy a blow at France, at England? At America also, of course; but she is the one of the three great countries who can't parry that blow, for she has put herself into the position of being open to attack, while deprived of the possibility of attacking.

That is perhaps the strangest phase of the entire international situation. The American Sammies could not now be sent to Italy even if everybody were willing to have them go there; for America would, by helping her ally, Italy, find herself fighting a country with which she is not in a state of war—or rather a country with which she does not want to acknowledge herself to be in a state of war. The vast majority of Americans realize today the absurdity of a situation pregnant with dangers to their country, and typical of that state of faulty coöperation which has been responsible for so many Allied reverses. Is not today the time to act? When tomorrow the first ship-loads of wounded, gassed, mutilated Sammies are landed here, and the streets of every American city become gradually filled with people in mourning, and the making of artificial limbs and eyes becomes one of the most productive industries in the country, then the German spy situation will be dealt with, with determination, and all suspects will be put in a place where they can do no harm. What will happen then to their Austrian colleagues who have shown such splendid sense of coöperation with the Germans when it came to the blowing up of munition plants or the destruction of Allied shipping? And does not America realize that while today her boys are sailing mysteriously for Europe, and no German can cable such news to Berlin, any Austrian is at liberty to cable it to Vienna by merely wording it in a way which would make the message appear harmless to the censor? Does she not realize that such news, that *any* news, can actually be cabled in full, without resorting to any device, by the Bulgarian Embassy in Washington, which is still doing its work unhampered, for a country whose forces are ruled by that very Potsdam clique upon which America is hurling all her available manhood?

It is not lack of willingness; it is not lack of sympathy; it is inexcusable though not yet irreparable lack of coöperation. This I say today as I look upon a war map of the Old World, which shows a fantastic massing of troops upon the most difficult front of the war, a scattering of forces over distant and semi-colonial fronts in eastern Europe and western Asia, and the heart-rending retreat through the Venetian plains of a heroic army allowed to fight single-handed against that formidable Austro-German coalition which learned long ago the one secret of success—coöperation.

Trans-Atlantic Airships

(*Concluded from page 442*)

that these could be made sufficiently light, strong, and gas-tight. *This chafing has not and cannot be remedied.* And it is this very chafing which is responsible for nearly all the sinkings at sea or the landings in an exhausted condition. The only possible remedy for this defect is the abandoning of the frame with its cells and partitions and its outside cover, *i. e.*, of the essential features of the rigid Zeppelin airship.

To this Zeppelin never would consent. Another drawback arises from the fact that the cells are never full of gas. At the filling, a certain space has to be reserved for the expansion of the gas. When the ship rises to its flying altitude, the gas finds its way out of the cell through the safety valve disposed for this purpose, and escapes between the cells and the outer cover into the atmosphere. After a certain number of hours, the cells are partly empty; the fabric, sucked back to the lower part of the bubble of gas, hangs down like a curtain. Any motion of the ship creates a wave of gas; the fabric

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follows it, the surfaces rubbing against each other become charged with static electricity in sufficient quantity and of such high tension as to give birth to sparks closely followed by explosions and conflagration and utter destruction. Such are the sad records of disaster at Echterdingen, Berlin and other places. For these reasons, to say nothing of many others of less importance, the Zeppelin airship never will be, and never can be, an efficient trans-oceanic airship. And to increase their size and power would merely be to multiply their defects.

The eye of the German navy is not at present ready for an inquisitive glance over Uncle Sam's Atlantic shores or sea routes. It may be so in the near future, sooner than we expect, perhaps, but not just yet. The trans-oceanic airship as the eye of the navy, the patrol of the sea routes, the eagle foe of the submarine, the fast carrier linking Washington with Europe, is today the most vital, the most urgent, necessity. American prestige will not lose through it. Presently, the aeroplane is out of the question. Its carrying capacity is not sufficient. To be of any practical use the trans-oceanic airship must be able, in the first place, to bridge the Atlantic any time of the year, within 60 hours, carrying a net cargo of 20 tons as a minimum. Any airship of lesser capacity will prove a failure. The ship has to be designed and constructed under the imperative rule of aeronautics, *i. e., "anything that is not absolutely necessary is worse than useless and must be cut out."* Zeppelin has clearly shown us what not to do; three-quarters of the difficulties are over; the other quarter has been cleared up by the patient, admirable and thoroughly scientific work of the Hydrographic Bureau of the U. S. Navy, the Weather Bureau, and the Meteorological Station of Blue Hill. Without going into many details, I may say that the ocean routes have been thoroughly surveyed. The navy that flies can proceed on its errands in all security and with full dispatch.

The design of the airship, as illustrated, becomes a simple one: no rigid frame, no spider-webbed partitions, no sagging or flapping cover tearing loose, no cells throwing off excess gas, no transverse partitions affecting stream lines. Not impeded by any of the Zeppelin considerations, the lines of the ship are the finest that can be designed. The head resistance is reduced to the "minimum-minimorum." The fore part only is reinforced by an inside collapsible, umbrella-like frame, expanded to suit the shape of the skin. The ribs of this frame run in parallel lines to the longitudinal axis. The gas bag is made of three-ply strong cotton fabric with stout caoutchouc insertion. Owing to the fact that woof and warp are crossed at 45 degrees to each other, and that the whole is warm-vulcanized, the fabric can not rend.

The division of the gas bag into tight compartments is, therefore, needless. A keel, built of three-ply wood reinforced by aluminum insertions, and stiffened by split bamboos, carrying the engines, propellers, rudders, petrol, cargo, implements, wireless equipment, crew and passengers, is fixed to the gas bag by means of two long pieces of fabric shaped to fit and enclose the car, thus giving to the whole the appearance of the hull of a gigantic racing yacht.

The length of the keel has been determined by the lifting curve of the gas, and the load has been so distributed as to avoid any excessive stress or heavy bending movement. As the load of petrol is being burnt, the corresponding lift of gas is likewise disposed of, leaving the equations of the keel absolutely undisturbed.

The suspension pieces as well as the hull itself are kept taut and in constant shape by the pressure of the gas inside; some fifty to sixty kilos per square meter (about 110 pounds to the square yard). This pressure is regulated by an air ballonet extending all over the keel, inside of the gas bag. Hot or cold air can be forced into it by means of powerful ventilators, and kept under constant pressure by a set of well-regulated safety valves. The

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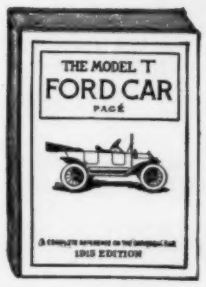

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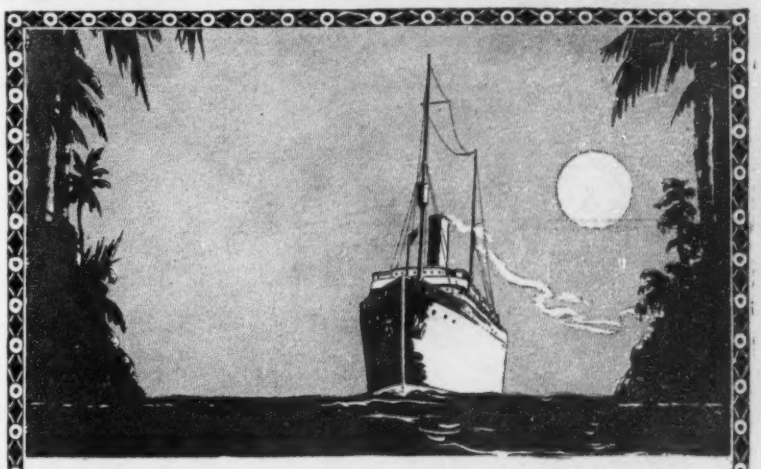

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engine rooms in the keel are thus separated from the gas by a layer of air constantly renewed. All traces of diffused gas being constantly removed, the danger of explosion or fire due to the prox.mity of the engines, is definitely removed.

The engines, designed by the world-known French engineer, Farcot, are of a vertical type with horizontal cylinders set in two planes. They are carefully balanced so as to avoid destructive vibrations. Each one of the two-throw cranks receives in group the connecting rods of five pistons. As these are opposed in direction, the masses in motion, moving against and from each other, gives the engine a free and sweet running. This engine can be worked on petrol alone, or on the hydrogen gas of the airship, or on any variable quantity of both. This is obtained by a set of two pumps working on the same cam, one for the petrol the other for the gas. The cam can be so adjusted as to command at will either the petrol, pump o: the gas pump alone, at full stroke, or both at variable stroke.

As one kilogram of petrol burned in the engines means an excess of lift of one cubic meter of gas, petrol and gas can be fed to the engines in such proportions as to fit the equilibrium of the airship. Should it be found desirable to bring the airship to lower levels, gas only would be fed, while on the other hand, if the airship must be brought to higher altitudes, petrol only would be the fuel; finally, if the airship is to be navigated at a constant altitude, both petrol and gas should be used in correct ratio.

The disturbing effects of sun, rain, snow or sleet can be checked, further, by the cold or hot ventilation of the ballonet, the elevating planes and the swinging of the propellers. The latter can be rotated into any desired position so as to propel, at will, forward, backward, downward, or upward. As the push of the four propellers amounts to some eleven tons, the trans-oceanic airship is well prepared to meet any fall of wet snow however heavy it may be. No sinking at sea is possible.

Still another advantage is gained through the use of hydrogen in the motor. The calories evolved by the combustion of this gas are roughly equivalent to the calories evolved by the combusion of one third the same amount of petrol; so this means a longer journey for the same amount of petrol. In trans-oceanic aerial travel, this proves to be a very important and respectable factor, worthy of consideration.

The engines, located fore and aft, are connected by means of clutches to a pair of double propellers revolving in opposite directions, making for utmost efficiency. Propellers can be thrown in or cut of gear at will in order to assist horizontal or vertical steering.

The general data of the proposed aerial liner are as follows:

Length 351 meters (1,150 feet).

Diameter 27 meters (88 feet).

Elongation 13 to 1.

Cubic capacity 100,000 cubic meters (3,531,400 cubic feet).

Horse-power 2,500.

Speed 110 kilometers per hour (68 miles per hour).

Range of action 5,000 miles.

Net cargo capacity 20 tons.

The establishment of two bases, one on each side of the Atlantic, and the construction of the first two trans-oceanic flyers would require $5,000,000 and 210 days of work. The construction of further bases and further airships would cost very much less.

The immediate construction of such airships at the present time means more to the American nation than the mere supremacy of the air. As the eye of the navy, a good, powerful, clear and quick eye with a strong and far-reaching wireless nerve, it means the safety of the sea routes. It should prove the most formidable weapon turned against the submarine.

As a carrier of news it should facilitate the heavy task bearing upon the President and the Government, since it could relieve anxious hearts at home by bringing quickly to them the news of their brave ones fighting far away for Right and Liberty.

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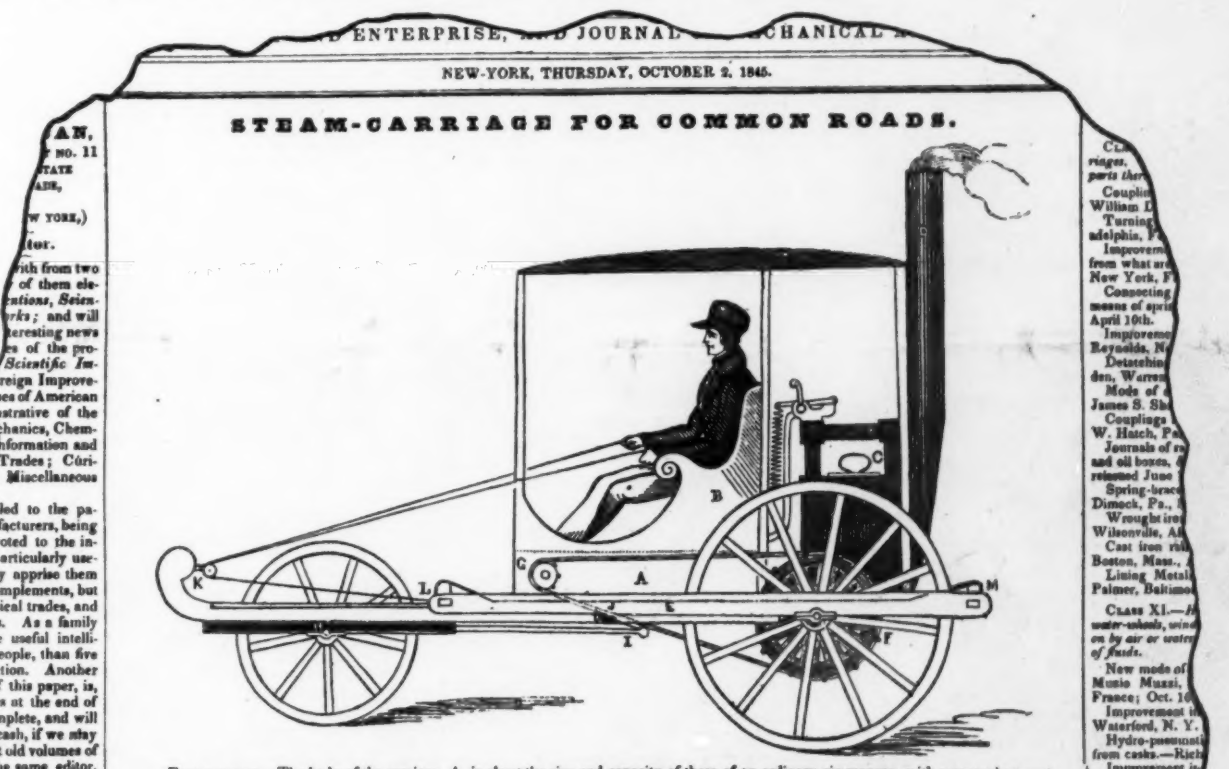
Back in 1845 the SCIENTIFIC AMERICAN took up the cause of the motor-driven road vehicle, and ever since then it has maintained its position as the leading authority in this field which has led up to the motor cars of the present day. Incidentally, some of the statements made in its columns in the issue of October 2nd, 1845, and reprinted below, have come true.



ENTERPRISE, AND JOURNAL OF MECHANICAL

NEW-YORK, THURSDAY, OCTOBER 2, 1845.

STEAM-CARRIAGE FOR COMMON ROADS.

EXPLANATION.—The body of the carriage, A, is about the size and capacity of those of an ordinary gig-waggon, with a convenient seat, B, for two riders; and under the seat is a box that will contain two or three bushels of coal. Behind the seat is the boiler, C, which consists principally of two rows of copper tubes, placed in a vertical position: and the two rows being parallel to each other, and ten inches apart, the fire is contained in the space between them, and is restrained from coming in contact with the tubes above the surface of the water within them: the smoke escapes by the funnel, O. A strong frame consisting of two parallel beams, E, connected by cross-bars, is made large enough to enclose the driving wheels, F, which are put in motion by an endless chain, which passes from the wheel, over the pulley, G; and the shaft of this pulley, passing through the body of the carriage, has a double crank under the floor of the carriage, and nearly under the rider's feet; and this crank is operated by two small engines, which are placed horizontally under the floor, and are operated by steam, which is conducted to them through a small pipe, from the top of the boiler. This carriage has but three wheels; and the forward or steering wheel, has its bearings in the sides of a horizontal circle, H. This horizontal circle is so constructed and mounted as to be moved rotarily on its own centre; and from the rearward side of this circle, a lever projects horizontally to I; and from the extreme end of this lever, a cord passes horizontally to the sides of the frame, near J; thence forward and over another pulley, K, and thence to the hands of the rider, where it meets another similar cord from the lever via the opposite side of the carriage. Thus by pulling one cord the steering-wheel is turned in one direction, and *vice versa*. The body of the carriage is hung on straps or braces extending from L to M, which secures the rider and machinery from any violent jolting which might otherwise be occasioned by the roughness of the roads. There is an arrangement in the machinery, which we shall describe, with an illustrative engraving, in a future number, and by which the power of the engines is applied to both driving-wheels equally and uniformly, notwithstanding the occasional excess of motion in one of the wheels, in passing corners or curves in the roads. Another peculiarity is, that the force applied, may be occasionally increased by leverage,—consequently reducing the speed,—to such an extent that one horse-power of steam will propell as great a load up-hill or otherwise, as can be drawn by six horses. One of the uses to which this carriage is intended to be applied, is to draw a plough or harrow; lift stumps and rocks, and do other agricultural work. For ploughing it will be requisite to have the rims of the wheels wider than for travelling, and the tire of the wheels must be furnished with teeth or projections to prevent the sliding of the wheels on the ground.

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